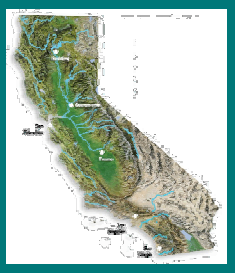
USDA Forest Service
Pacific Southwest Region



# Best Management Practices Evaluation Program

## 1992-2002 Monitoring Results

November 2004

## EXECUTIVE SUMMARY

The United States Forest Service (USFS), Pacific Southwest Region (Region 5) initiated its Best Management Practices Evaluation Program (BMPEP) in 1992. This program fulfills monitoring commitments to the State Water Resources Control Board (SWRCB) and facilitates adaptive management by assessing and documenting the efficacy of the USFS water quality management program. The BMPEP employs 29 different onsite (activity-level) monitoring procedures to evaluate the implementation and effectiveness of BMPs for a variety of activities in seven different program areas: timber, engineering, recreation, grazing, mining, prescribed fire, and vegetation management.

Since the BMPEP's inception, over 5,000 onsite evaluations have been conducted on the 18 national forests in California. Results from over 3,000 of these evaluations performed at randomly selected sites from 1992 through 2002 were analyzed to assess the performance of the USFS Region 5 water quality management program. Results indicate that while some improvements are necessary, the program performed reasonably well during that period of time. BMP implementation and effectiveness were relatively high for most activities and elevated effects on water quality and beneficial uses of water were relatively infrequent, particularly in recent years. In addition, both the BMPs and the BMPEP have been expanded and improved since monitoring results were last reported in 1998.

Key findings of the analysis include the following:

- From 1992 through 2002, an average of 357 random evaluations were conducted annually throughout the Region. This ranged from a high of 599 sites in 1996 to a low of 109 sites in 2000. Monitoring rebounded steadily to 301 and 425 sites in 2001 and 2002, respectively.

- A statistically significant relationship between BMP implementation and effectiveness was found for 16 of the 29 monitoring protocols ($p<0.10$). This demonstrates that for the activities evaluated by these 16 protocols, those with adequate BMP implementation are more likely to meet onsite water quality protection objectives than those without BMPs. The size or distribution of results was not adequate to demonstrate statistically significant relationships for the other 13 protocols. Ongoing database work will allow for eventual analysis of additional data, which will likely increase the number of evaluations with demonstrated associations.

- BMP Implementation

  - For all activities combined, BMPs were implemented at 85% of observation sites during the 1992-2002 monitoring period. Implementation rates from 1997 through 2002 were similar to those from 1992 through 1996.
  - From 1992 through 2002, BMP implementation rates were 87% for timber, 85% for engineering, 68% for recreation, 77% for prescribed fire, and 87% for vegetation management. Only qualitative results were available for grazing and mining.
  - Quantitative implementation rates were available for 24 of 29 protocols. Implementation rates for these varied between 50% and 100%. Rates were 90% or greater for nine of the 24 evaluations, 85% or greater for 14 of them, and 80% or greater for all but six evaluations. Only two evaluations had implementation rates less than 75%.
  - Between the first and second half of the 1992-2002 monitoring period, implementation rates increased by 5% or more for six of the 24 protocols for which quantitative data were available. Decreases of 5% or more occurred for five evaluations.
  - BMP implementation rates for individual forests ranged from 60% to 96%. Implementation was 80% or greater on 14 of 18 forests and 75% or greater on all but one Forest.

- BMP Effectiveness
  - From 1992 through 2002, BMPs for all activities combined were effective at 92% of the sites at which they were implemented. These rates were similar between the 1992-1996 and 1997-2002 monitoring periods.
  - BMPs were effective 94% of the time for timber, 89% for engineering, 89% for recreation, 98% for prescribed fire, and 89% for vegetation management. Only qualitative results were available for grazing and mining.
  - During the 11-year monitoring period, BMP effectiveness rates for individual evaluations ranged from 69% to 100%. These rates were 90% or greater for 15 of 24 evaluations with quantitative data and 85% or greater for all but three of them. Only one protocol had effectiveness rates less than 80%.
  - Effectiveness rates associated with two protocols increased by 5% or more between the first and second half of the 1992-2002 monitoring period. Decreases of more than 5% occurred for three evaluations.
  - BMP effectiveness rates on individual forests varied between 82% and 99%. Thirteen of 18 forests had rates of 90% or greater.

- When effectiveness problems were evident at project sites, field observers evaluated and commented on probable effects to beneficial uses of water. Observers' comments were used to classify likely effects with respect to their magnitude, extent, and duration and to establish an overall effects ranking. For all activities combined, water quality effects were classified as elevated at 78 (2%) of the sites monitored from 1992 through 2002. Most of these were related to engineering practices (46, <3% of engineering sites). Roads and in particular, stream crossings, were the most problematic. Twenty were associated with timber practices (<2%) and four (2%) occurred at recreation sites. Five (<4%) were related to grazing, one (<1%) resulted from a prescribed fire, one (<1%) was observed at a mining site, and one (<1%) was associated with vegetation management. The number of elevated effects observed between the first and second half of the 1992-2002 monitoring period was relatively similar for all practices, except those associated with road stream crossings. There were substantially more crossings with effects ranked as elevated during the second half of the 1992-2002 monitoring period than the first. This was primarily due an increased number of failures associated with the significant storms of 1997.

- Effects classified as elevated were typically caused by lack of or inadequate BMP implementation. Nonetheless, elevated effects occurred at some sites despite implementation of BMPs. These occurrences were infrequent and typically due to large storm events and/or especially sensitive site conditions.

- To facilitate adaptive management, monitoring results were used to identify and prioritize 25 issues and associated corrective actions. Nine of these relate to overall program management, including training, completion of revision to monitoring protocols, and consistent monitoring, analysis, and reporting. Three issues pertain to timber management, specifically streamside management zones, skid trails, and landings. Six issues were associated with engineering practices, including water source development, in-channel construction, snow removal, restoration of borrow pits and quarries, stream crossings, and road surfacing, drainage, and slope protection. The final seven issues involve recreation, grazing, mining, and prescribed fire, where an increased focus on BMP implementation is necessary.

- The USFS has implemented several other monitoring programs, including instream monitoring, to complement the BMPEP onsite evaluations. Together, these programs address a range of monitoring issues including project-level implementation and effectiveness of BMPs, validation of BMP effectiveness, compliance with regulatory standards, assessment of status and trends in water quality and aquatic resources, and evaluation of cumulative watershed effects (CWE).

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# 1. INTRODUCTION

This report summarizes the results of the United States Forest Service (USFS), Pacific Southwest Region (Region 5), Best Management Practices Evaluation Program (BMPEP) from 1992 through 2002. The objectives of the BMPEP are to: 1) fulfill USFS monitoring commitments to the State Water Resources Control Board (SWRCB), as described in the SWRCB/USFS Management Agency Agreement (SWRCB/USFS 1981) and *Water Quality Management for National Forest System Lands in California (USFS 2000)*; and 2) facilitate adaptive management by assessing and documenting the efficacy of the USFS water quality management program, specifically the implementation and effectiveness of Best Management Practices (BMPs).

Onsite Evaluations are the foundation of the BMPEP and are therefore the focus of this report. Results of these evaluations are described in Section 2. The USFS has also implemented several other monitoring programs, including stream monitoring, to compliment the Onsite Evaluations. These are described in Section 3. Together, these programs address a range of monitoring issues including project-level implementation and effectiveness of BMPs, validation of BMP effectiveness, compliance with regulatory standards, assessment of status and trends in water quality and aquatic resources, and development and validation of cumulative watershed effects (CWE) models.

# 2. ONSITE EVALUATIONS

## *2.1. Objectives and Methods*

Onsite Evaluations are used to assess BMP *implementation* and *effectiveness*. Implementation evaluations determine the degree to which planned, prescribed, or required water quality protection measures were actually put in place on project sites. Effectiveness evaluations gauge the extent to which these practices met their onsite water quality protection objectives.

Twenty-nine Onsite Evaluation protocols are used to assess the implementation and effectiveness of individual BMPs or groups of closely related BMPs. Table 1 identifies each of these protocols and the corresponding BMPs they are designed to evaluate. Additional details regarding the BMPs and BMP evaluation protocols can be found in *Water Quality Management for National Forest System Lands in California (USFS 2000)* and *Investigating Water Quality in the Pacific Southwest Region, Best Management Practices Evaluation Program User's Guide (USFS 2002).*

Onsite Evaluation protocols are applied at both randomly and non-randomly selected project sites. The number of random evaluations to be completed each year are assigned to each National Forest by the Regional Office based on: 1) the relative importance of the BMP in protecting water quality in the Region; 2) those management activities most common on individual forests (e.g., grazing is emphasized on the Modoc National Forest, recreation is emphasized on the Angeles National Forest); and (3) identified problems with specific practices. Forests supplement these randomly

.**TABLE 1: BMPEP Onsite Evaluation Protocols and associated BMPs**

| BMPEP Onsite Evaluation Protocol[1] | BMPs Evaluated[2] |
|---|---|
| T01: Streamside Management Zones (SMZs) | ▪ SMZ Designation (1-8)<br>▪ Streamcourse and Aquatic Protection (1-19)<br>▪ Slash Treatment in Sensitive Areas (1-22) |
| T02: Skid Trails | ▪ Tractor Skidding Design (1-10)<br>▪ Erosion Control on Skid Trails (1-17) |
| T03: Suspended Yarding | ▪ Suspended Log Yarding in Timber Harvesting (1-11) |
| T04: Landings | ▪ Log Landing Location (1-12)<br>▪ Log Landing Erosion Control (1-16) |
| T05: Timber Sale Administration | ▪ Erosion Prevention & Control Measures During Timber Sale Operations (1-13)<br>▪ Erosion Control Structure Maintenance (1-20)<br>▪ Acceptance of Timber Sale Erosion Control Measures Before Sale Closure (1-21)<br>▪ Modification of Timber Sale Contract (1-25) |
| T06: Special Erosion Control & Revegetation | ▪ Special Erosion Prevention Measures on Disturbed Land (1-14)<br>▪ Revegetation of Areas Disturbed by Harvest Activities (1-15) |
| T07: Meadow Protection | ▪ Meadow Protection During Timber Harvesting (1-18)<br>▪ Slash Treatment in Sensitive Areas (1-22)<br>▪ Tractor Operation Limitation in Wetlands and Meadows (5-3) |
| E08: Road Surface, Drainage & Slope Protection | ▪ Erosion Control Plan (2-2)<br>▪ Stabilization of Road Slope Surfaces and Spoil Disposal Areas (2-4)<br>▪ Road Slope Stabilization Construction Practices (2-5)<br>▪ Control of Drainage (2-7)<br>▪ Construction of Stable Embankments (2-10)<br>▪ Maintenance of Roads (2-22)<br>▪ Road Surface Treatments to Prevent Loss of Materials (2-23) |
| E09: Stream Crossings | ▪ General Guidelines for Location and Design of Roads (2-1)<br>▪ Stabilization of Road Slope Surfaces and Spoil Disposal Areas (2-4)<br>▪ Road Slope Stabilization Construction Practices (2-5)<br>▪ Control of Road Drainage (2-7)<br>▪ Construction of Stable Embankments (fills) (2-10)<br>▪ Stabilization of Road Slope Surfaces and Spoil Disposal Areas (2-4) |
| E10: Road Decommissioning | ▪ Obliteration or Decommissioning of Roads (2-26) |
| E11: Control of Sidecast Material | ▪ Control of Sidecast Material During Construction & Maintenance (2-11) |
| E12: Servicing and Refueling | ▪ Servicing and Refueling of Equipment (2-12) |
| E13: In-Channel Construction Practices | ▪ Controlling in-Channel Excavation (2-14)<br>▪ Diversion of Flows Around Construction Sites (2-15)<br>▪ Bridge and Culvert Installation (2-17) |
| E14: Temporary Roads | ▪ Stream Crossings on Temporary Roads (2-16)<br>▪ Obliteration or Decommissioning of Roads (2-26) |
| E15: Rip Rap Composition | ▪ Specifying Rip Rap Composition (2-20) |
| E16: Water Source Development | ▪ Water Source Development Consistent with Water Quality Protection (2-21) |
| E17: Snow Removal | ▪ Snow Removal Controls to Avoid Resource Damage (2-25) |
| E18: Pioneer Road Construction | ▪ Timing of Construction Activities (2-3)<br>▪ Constraints Related to Pioneer Road Construction (2-8)<br>▪ Timely Erosion Control Measures on Incomplete Road and Stream Crossing Projects (2-9) |

[1] The R21 protocol (Designated Swimming Areas) no longer exists because the USFS no longer designates swimming areas.

[2] The BMP reference numbers as listed in USFS (2000) are provided in parentheses.

.**TABLE 1: BMPEP Onsite Evaluation Protocols and associated BMPs**

| BMPEP Onsite Evaluation Protocol[1] | BMPs Evaluated[2] |
|---|---|
| | ▪ Disposal of Right-of-way and Roadside Debris (2-19) |
| E19: Restoration of Borrow Pits & Quarries | ▪ Regulation of Streamside Gravel Borrow Areas (2-18)<br>▪ Obliteration or Decommissioning of Roads (2-26)<br>▪ Restoration of Borrow Pits and Quarries (2-27) |
| E20: Protection of Roads During Wet Periods | ▪ Traffic Control During Wet Periods (2-24)<br>▪ Management by Closure to Use (7-7) |
| R22: Developed Recreation sites | ▪ Control of Sanitation Facilities (4-4)<br>▪ Control of Solid Waste Disposal (4-5)<br>▪ Assuring that Organizational Camps Have Proper Sanitation and Water Supply Facilities (4-6)<br>▪ Protection of Water Quality Within Developed and Dispersed Recreation Areas (4-9)<br>▪ Location of Pack and Riding Stock Facilities and Use in Wilderness, Primitive, and Wilderness Study Areas (4-10) |
| R23: Location of Stock Facilities in Wilderness | ▪ Location of Pack and Riding Stock Facilities and Use in Wilderness, Primitive, and Wilderness Study Areas (4-10) |
| G24: Range Management | ▪ Range Analysis and Planning (8-1), Grazing Permit System (8-2), Rangeland Improvements (8-3) |
| F25: Prescribed Fire | ▪ Consideration of Water Quality in Formulating Fire Prescriptions (6-2)<br>▪ Protection of Water Quality from Prescribed Burning Effects (6-3) |
| M26: Mining Operations (Locatable Minerals) | ▪ Water Resources Protection on Locatable Mineral Operations (3-1)<br>▪ Administering Terms of BLM-Issued Permits or Leases for Mineral Exploration and Extraction on NFS Lands (3-2) |
| M27: Common Variety Minerals | ▪ Administering Common Variety Mineral Removal Permits (3-3)<br>▪ Regulation of Streamside Gravel Borrow Areas (2-18) |
| V28: Vegetation Manipulation | ▪ Soil Disturbing Treatments on the Contour (5-1)<br>▪ Slope Limitations Mechanical Equipment Operation (5-2)<br>▪ Disposal of Organic Debris (5-5)<br>▪ Soil Moisture Limitations for Tractor Operations (5-6) |
| V29: Revegetation of Surface Disturbed Areas | ▪ Revegetation of Surface Disturbed Areas (5-4) |
| R30: Dispersed Recreation | ▪ Control of Sanitation Facilities (4-4)<br>▪ Control of Solid Waste Disposal (4-5)<br>▪ Assuring that Organizational Camps Have Proper Sanitation and Water Supply Facilities (4-6)<br>▪ Protection of Water Quality Within Developed and Dispersed Recreation Areas (4-9)<br>▪ Location of Pack and Riding Stock Facilities and Use in Wilderness, Primitive, and Wilderness Study Areas (4-10) |

selected sites with additional ones based on local monitoring needs, such as those prescribed in environmental documents. Results associated with randomly selected sites are the focus of this report, since only those sites can be used to programmatically assess BMP implementation and effectiveness in an unbiased manner.

Monitoring procedures vary greatly, but the overall approach for each Onsite Evaluation is consistent. For BMP implementation, evaluators are asked a variety of specific questions intended to determine whether projects were executed as planned and described in project documents. A numeric score is allocated to each question, depending on its relative importance and the degree to which the particular aspects of the BMP were met (e.g., whether the project exceeds, meets, departs insignificantly, or departs substantially from requirements). Scores for all implementation questions are then summed to create an overall implementation score. This score is subsequently compared to a decision threshold, selected *a priori*, to determine whether a given BMP or suite of BMPs is considered to have been implemented. BMP effectiveness is assessed independently based on indirect, site-level measures of water quality protection. These include observations (e.g., evidence of sediment delivery to channels) and quantitative measurements (e.g., amount of ground cover, percent of stream shade). A scoring system similar to that used for BMP implementation is used to assess BMP effectiveness. These scoring algorithms are applied automatically by the Regional BMPEP database, which stores all of the monitoring data.

This scoring approach results in a two-by-two matrix, where a given BMP or suite of BMPs are placed into one of four categories: implemented and effective (I-E); implemented, but not effective (I-NE); not implemented, but effectiveness objectives were met (NI-E); and not implemented and effectiveness objectives were not met (NI-NE). For sites with poor implementation or effectiveness scores, observers are asked to identify possible reasons and suggest corrective actions. Evaluators also use professional judgment to estimate the magnitude, duration, and extent of any likely or observed impacts to water quality.

Previously, results of these impact assessments were only recorded as comments. Recently, however, these assessments have been expanded to include a categorical ranking using the criteria described in Table 2 (see Section 2.2 for details). To provide consistency in this report, potential water quality impacts were assessed against the new criteria, whether they were evaluated before or after these criteria were adopted. This was achieved by comparing database comments, to the degree possible, against the new criteria. Subsequently, a weight-of-evidence approach was used to establish an overall effects ranking (minor, moderate, elevated) for each site. Only those sites with effects ranked as elevated are discussed in this report because they are the most important and the certainty associated with the classification of these sites is much higher than those for the other two categories. This is due to the fact that discriminating between sites with minor and moderate effects through *ex post facto* application of these criteria was much more difficult than identifying those with likely elevated effects. Because field evaluators have always been directed to describe potential water quality impacts when effectiveness problems were evident, it was assumed that an activity did not have elevated effects on water quality or beneficial uses if there were no such indications in the database comment fields.

**TABLE 2: Newly Adopted Categories of Effects on Water Quality and Beneficial Uses of Water.**

| Effect Attribute | Category | Description |
|---|---|---|
| **Magnitude** | Minor | Pollutant was not likely (is not) observable and effects to beneficial uses were (are) unlikely. |
| | Moderate | Pollutant was likely (is) observable and effects to beneficial uses were (are) likely, but small. |
| | Elevated | Pollutant or effects to beneficial uses were likely (are) obvious and substantial. |
| **Duration** | Minor | The pollutant and/or its effects likely lasted (or will likely last) <5 days. Effects are typically associated with a single activity or precipitation event. |
| | Moderate | The pollutant and/or its effects likely lasted (or will likely last) > 5 days, but <1 season. Effects are typically expressed intermittently during high flow or precipitation events, dissipating to near background levels by the next season. |
| | Elevated | The pollutant and/or its effects likely lasted (or will likely last) >1 season. Effects are typically chronic. |
| **Extent** | Minor | Pollutant moved off-site, but did not reach the stream channel. |
| | Moderate | Pollutant moved off-site and reached the stream channel. Effects are evident at the stream reach scale (<20 channel widths downstream). |
| | Elevated | Pollutant moved off-site and reached the stream channel. Effects are evident at the drainage scale (>20 channel widths downstream) and typically extend downstream and are expressed in larger order channels. |

## *2.2. Program Updates*

Between 1999 and 2002, several changes were made to the Onsite Evaluations. First, two new protocols, one for road decommissioning (E10) and one for dispersed recreation (R30), were added to address these increasingly important activities on national forests in California. In addition, changes to several existing protocols were made based on a comprehensive, interdisciplinary review by specialists and program managers from the forests and the Regional Office. A detailed description of issues identified in the review and actions taken to resolve them are described in Table A-1 (appendix). This included the adoption of more objective, categorical, and quantifiable criteria for assessing the extent, duration, and magnitude of potential effects on water quality (Table 2). Besides protocol changes, significant database modifications were completed in 2002. This work corrected discrepancies between the database and field forms, incorporated the new and modified protocols, made reporting more user-friendly, and modernized the computer code. More database work was initiated in 2003 to address additional needs.

Due to the issues described in Table A-1, some monitoring data were not quantitatively analyzed (i.e., implementation and effectiveness rates were not determined) for this report (Table 3). No results are included for those data that can and eventually will be analyzed and reported quantitatively once the ongoing database work is completed. Because there were problems with some previous monitoring protocols, quantitative analysis of other data will not be possible even after the database is finalized. Consequently, these data were analyzed qualitatively (e.g., important implementation and effectiveness questions were evaluated) and the results of that analysis are included in this report.

**TABLE 3: Data excluded from quantitative analysis in this report.**

| BMPEP Onsite Evaluation Protocol | Data excluded from quantitative analysis | # of evaluations excluded from quantitative analysis | # of evaluations analyzed qualitatively | # of evaluations to be recovered & quantitatively analyzed in the future | # of evaluations excluded from any analysis | Reason[3] |
|---|---|---|---|---|---|---|
| T03 | 1992-2002 | 95 | 0 | 95 | 0 | Ongoing database modifications will allow for eventual quantitative analysis. |
| T06 | 1992-2001 | 57 | 0 | 57 | 0 | See T03. |
| E13 | 1992-2001 | 108 | 108 | 0 | 0 | Problems with previous protocols preclude quantitative analysis. |
| E18 | 1992-2001 | 25 | 0 | 25 | 0 | See T03. |
| R22 | 1992-2001 | 142 | 142 | 0 | 0 | See E13. |
| R23 | 1992-2002 | 46 | 0 | 46 | 0 | See T03. |
| G24 | 1992-2002 | 152 | 130 (1992-2001 data) | 0 | 22 (2002 data) | Problems with previous protocols preclude quantitative analysis of 1992-2001 data. The 22 sites collected in 2002 were used for pilot testing a draft version of a new protocol. This pilot testing identified other issues that need to be addressed before the protocol is finalized. Consequently, results of this monitoring are not reported here and will not be reported in the future. Implementation of the revised protocol is scheduled for 2005 or 2006. |
| M26 | 1992-2002 | 88 | 80 (1992-2001 data) | 8 (2002) | 0 | Problems with previous protocols preclude quantitative analysis of 1992-2001 data. Ongoing database modifications will allow for eventual quantitative analysis and subsequent reporting of data collected after 2001. |
| M27 | 1992-2002 | 93 | 0 | 93 | 0 | See T03. |
| TOTAL | | 806 | 460 | 324 | 22 | |

## *2.3.Interpretation and Reporting of Monitoring Results*

This report describes implementation rates for each BMP and group of BMPs (e.g., engineering), the associated effectiveness rates, the percent of *all* monitored sites that met effectiveness objectives (i.e., did not exceed effectiveness thresholds), and the number and percentage of sites that had elevated effects on water quality and/or beneficial uses of water. Implementation rates are a direct measure of how well the USFS is executing its water quality management program. As described above, a BMP or suite of BMPs were considered "implemented" at a site if the overall implementation scores did not exceed the implementation thresholds. BMP effectiveness is a measure of how well BMPs, *when implemented*, meet effectiveness (i.e., onsite water quality protection) objectives. BMPs were reported

[3] See Table A-1 for details.

as "effective" at those sites where BMPs were implemented *and* the effectiveness objectives were met[4]. The percent of *all* monitored sites that met the effectiveness objectives, whether or not BMPs were implemented, is an indicator of the frequency that a given activity or group of activities posed little or no risk to water quality.[5] Finally, the number and percentage of sites classified as having elevated effects on water quality is an indicator of the frequency that effects, rather than *risks of effects*, were likely to have been expressed at monitoring sites. This is the most important measure of the program's performance.

As described earlier, Onsite Evaluations employ indirect, site-level measures to evaluate BMP effectiveness. Direct measurement of instream water quality parameters and comparison of those parameters to state water quality standards is not widely applied in these evaluations because this type of monitoring is extremely difficult and costly. This is primarily due to the fact that many pollutants of concern in forest and rangeland environments (e.g., sediment) are naturally occurring and differentiating between natural sources, current anthropogenic sources, and the effects of past activities poses significant challenges. In addition, the natural and human-caused sources of these pollutants are dispersed over large areas. Finally, because the concentrations of these constituents are highly variable at multiple spatial and temporal scales, detecting the effects of activities is not possible unless they are very large or the intensity of monitoring is very high and is conducted over long periods of time. Due to these limitations, this type of monitoring is being conducted in a few, intensely monitored sites such as the Kings River Experimental Watershed (Section 3).

Because these indirect measures are typically used, the BMPEP onsite monitoring does not provide absolute, definitive proof that water quality standards have been met at sites where BMPs have been ranked as effective. Nonetheless, because these indirect measures provide substantial evidence regarding whether pollutants were discharged to watercourses and if aquatic habitats have been altered significantly, it is very likely that water quality was protected at those sites where BMPs were ranked as effective. Poor effectiveness scores do not necessarily mean that a state water quality standard was violated or that beneficial uses were affected. Instead, they indicate that there were increased risks of impacts to water quality and beneficial uses at those sites. As described above, likely or actual impairment of water quality and/or beneficial uses of water are determined based on evidence at the site and application of professional judgment.

## *2.4. Results*

The following sections describe the results of the BMPEP monitoring program from 1992 through 2002. First is a discussion of the relationship between BMP implementation and effectiveness. This is followed by BMP implementation and effectiveness results for all activities combined, individual program areas (e.g., timber), and individual evaluations (e.g., streamside management zones). To illustrate temporal trends in BMP implementation and effectiveness, this report describes results for the *composite monitoring period* (1992-2002) as well as the *first monitoring period* (1992-1996) and *second monitoring period* (1997-2002).

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[4] Mathematically, "implemented" is (I-E + I-NE)/(total # of all monitored sites) and "effective" is (I-E)/(I-E + I-NE), where I-E, for instance, means the number of sites that are implemented and effective.

[5] Mathematically, this is (I-E + NI-E)/(total # of all monitored sites).

### 2.4.1. Relationship Between BMP Implementation and Effectiveness

Chi-Square analysis was used to test differences in effectiveness scores between sites where BMPs were and were not implemented. The hypothesis tested was that effectiveness scores are not dependent on implementation scores. As summarized in Table 4, results of this analysis indicate that at the 90% confidence level, there is a statistically significant relationship between BMP implementation and effectiveness for 16 of the 29 evaluation protocols (see Table A-2 for details). This demonstrates that for the activities evaluated by these 16 protocols, those sites where BMPs are implemented are more likely to meet the effectiveness objectives than those where they are not. Since these objectives are indirect measures of water quality protection, it follows that sites where BMPs are implemented are more likely to protect water quality than those where they are not. A statistically significant relationship was not found for six of the monitoring protocols. For the remaining seven evaluations, insufficient samples in at least one of the four result categories precluded the use of a chi-square test. Upon completion of ongoing database modifications, inclusion of the additional data described in Table 3 will allow chi-square tests to be performed for more protocols. This is likely to increase the number of evaluations with a demonstrated statistical relationship between BMP implementation and effectiveness.

**TABLE 4: Results of chi-square test of difference in effectiveness scores at sites where BMPs were and were not implemented.**

| Chi-Square Results | BMPEP Protocol |
|---|---|
| Statistically Significant ($p<0.10$) | T01, T02, T04, T07, E08, E09, E11, E12, E13, E14, E16, E17, E19, R22, F25, V28 |
| Not Statistically Significant ($p<0.10$) | T05, E10, E15, E20, V29, R30 |
| Test not Possible | T03, T06, E18, R23, G24, M26, M27 |

### 2.4.2. All Activities

A total of 5,007 BMP evaluations were conducted on the 18 National forests in California from 1992 through 2002 (Figure 1). These were performed at sites where timber, engineering, recreation, grazing, mining, prescribed fire, and vegetation management activities occurred. Of these evaluations, 3,932 were conducted at randomly selected sites. Quantitative results described in this report exclude data from 806 of these sites due to the protocol and database issues described earlier (Tables 3 and A-1). Consequently, the quantitative results are based on 3,126 random evaluations. Results of a qualitative analysis of 460 of the 806 sites are also included. An additional 324 sites will be quantitatively analyzed and reported once ongoing database modifications are complete. The remaining 22 sites were used to pilot test a draft revision to the grazing protocol.

On average, 357 random evaluations were conducted each year during the composite monitoring period. This fluctuated from a high of 599 sites in 1996 to a low of 109 sites in 2000. Monitoring rebounded steadily to 301 and 425 sites in 2001 and 2002, respectively. As shown in Figure 2, engineering BMPs

**FIGURES 1 & 2**

were the most commonly monitored practices from 1992 through 2002 (40% of all observations), followed by timber (35%), prescribed fire (6%), recreation (6%), vegetation management (5%), mining (5%), and grazing (4%). The total number of random evaluations completed by individual forests during the 1992-2002 monitoring period varied from 23 to 592 (Figure 3). All national forests except the San Bernardino and Los Padres evaluated more than 100 randomly selected sites. The Los Padres, however, has focused significant effort on evaluating non-randomly selected sites (144 since 1992).

For all evaluations combined, BMPs were implemented 85% of the time during the composite monitoring period (Figure 4). Implementation rates during the 1992-1996 and 1997-2002 monitoring periods were similar (Figure 5). By functional area, BMP implementation rates were 87% for timber, 85% for engineering, 68% for recreation, 77% for prescribed fire, and 87% for vegetation management. Only qualitative results for mining or grazing are reported for the reasons described previously (Tables 3 and A-1). BMP implementation rates for individual forests ranged from 60% to 96%. Implementation rates were 80% or greater for all but four forests (Angeles, Plumas, Shasta-Trinity, and Tahoe) and 75% or greater for all but one Forest (Angeles) (Figure 6).

During the composite monitoring period, BMPs for all activities were effective at 92% of the sites at which they were implemented (Figure 4). These rates were similar during the first and second monitoring periods (Figure 5). By functional area, BMPs were effective 94% of the time for timber, 89% for engineering, 89% for recreation, 98% for prescribed fire, and 89% for vegetation management. No quantitative data are available for grazing and mining practices. BMP effectiveness rates for individual forests varied from 82% to 99% during the 1992-2002 monitoring period (Figure 6). Thirteen forests had effectiveness rates of 90% or greater.

Considering all sites, including those where BMPs were and were not implemented, effectiveness objectives were met 87% of the time from 1992 through 2002 (Figure 7). Effectiveness objectives were met at 91% of timber, 84% of engineering, 74% of recreation, 96% of prescribed fire, and 87% of vegetation management activity sites. For all activities combined, water quality effects were classified as elevated at 78 (2%) of the sites monitored from 1992 through 2002 (Table 5). Most of these were related to engineering practices (46, <3% of engineering sites). Roads, especially stream crossings, were the most problematic. Twenty were related to timber practices (<2%) and four (2%) occurred at recreation sites. Five (<4%) were associated with grazing, one (<1%) resulted from a prescribed fire, one (1%) was observed at a mining site, and one (1%) was related to vegetation management. The number of elevated effects observed during the first and second monitoring periods was relatively similar for all practices, except those associated with road stream crossings. Substantially more elevated effects resulting from stream crossings occurred from 1997 through 2002 than from 1992 through 1996. Most of these were observed in 1997 or 1998 and many were caused by an increased number of failures triggered by the significant storms of 1997.

Details regarding different categories of BMPs, the causes of elevated effects, and actions necessary to address deficiencies are provided in the sections that follow.

**FIGURES 3 & 4**

# FIGURES 5 & 6

**FIGURE 7**

**TABLE 5: Summary of water quality effects classified as *elevated* due to their extent, duration, and/or magnitude.**

| | | Composite Monitoring Period (1992-2002) | | First Monitoring Period (1992-1996) | Second Monitoring Period (1997-2002) | 1997 and 1998 only | Date elevated effects were last observed |
|---|---|---|---|---|---|---|---|
| Activity | Total # Sites Evaluated | % of sites | # of sites | # of sites | # of sites | # of sites | |
| T01 | 278 | <3% | 7 | 3 | 4 | 4 | 1998 |
| T02 | 305 | <2% | 5 | 2 | 3 | 3 | 1998 |
| T04 | 420 | <2% | 7 | 3 | 4 | 4 | 1998 |
| T05 | 67 | 0% | 0 | 0 | 0 | 0 | N/A |
| T06 | 7 | 0% | 0 | 0 | 0 | 0 | N/A |
| T07 | 134 | <1% | 1 | 0 | 1 | 1 | 1997 |
| **All Timber** | **1211** | **<2%** | **20** | **8** | **12** | **12** | |
| E08 | 284 | <5% | 13 | 5 | 8 | 8 | 1998 |
| E09 | 362 | 6% | 22 | 3 | 19 | 12 | 2003 |
| E10 | 29 | 0% | 0 | 0 | 0 | 0 | N/A |
| E11 | 209 | <1% | 1 | 1 | 0 | 0 | 1995 |
| E12 | 42 | 0% | 0 | 0 | 0 | 0 | N/A |
| E13 | 132 | 2% | 3 | 2 | 1 | 0 | 1999 |
| E14 | 133 | 2% | 3 | 3 | 0 | 0 | 1995 |
| E15 | 25 | 0% | 0 | 0 | 0 | 0 | N/A |
| E16 | 78 | <3% | 2 | 1 | 1 | 1 | 1998 |
| E17 | 180 | 0% | 0 | 0 | 0 | 0 | N/A |
| E18 | 1 | 0% | 0 | 0 | 0 | 0 | N/A |
| E19 | 64 | 3% | 2 | 2 | 0 | 0 | 1995 |
| E20 | 66 | 0% | 0 | 0 | 0 | 0 | N/A |
| **All Engr** | **1605** | **<3%** | **46** | **17** | **29** | **21** | |
| R22 | 160 | <3% | 4 | 3 | 1 | 1 | 1997 |
| R30 | 16 | 0% | 0 | 0 | 0 | 0 | N/A |
| **All Rec** | **176** | **2%** | **4** | **3** | **1** | **1** | |
| **All Grazing (G24)** | **130** | **<4%** | **5** | **2** | **3** | **2** | **2002** |
| **All Fire (F25)** | **254** | **<1%** | **1** | **0** | **1** | **1** | **1997** |
| **M26** | **80** | **1%** | **1** | **1** | **0** | **0** | **1995** |
| V28 | 99 | 0% | 0 | 0 | 0 | 0 | N/A |
| V29 | 89 | 1% | 1 | 1 | 0 | 0 | 1994 |
| **All Veg Mngmt** | **188** | **<1%** | **1** | **1** | **0** | **0** | |
| **All BMPs** | **3644** | **2%** | **78** | **32** | **46** | **37** | |

### 2.4.3. Timber Management

From 1992 to 2002, BMP implementation and effectiveness were evaluated at 1,363 different components (e.g., skid trails, landings) of randomly selected timber projects throughout the Region. Because 95 evaluations for suspended yarding (T03) and 57 evaluations for special erosion control and revegetation (T06) have been excluded from this analysis, the following results are based on 1211 of those sites. From 1992 through 2002, timber BMPs were implemented at 87% of observation sites (Figure 8). Implementation rates were relatively similar, but slightly lower, during the second monitoring period than the first (85% vs. 89%). For individual evaluations, average implementation rates during the composite monitoring period varied between 83% for streamside management zones (SMZs, T01) and 94% for timber sale administration (T05)[6]. Implementation rates were 89% or greater for all timber BMPs except those pertaining to streamside management zones (T01) and skid trails (T02).

Implementation rates for meadow protection (T07) increased moderately between the first (1992-1996) and second (1997-2002) monitoring periods (89% to 97%), but rates declined moderately for some other practices. These include SMZ protection (T01, 86% to 80%), skid trails (T02, 86% to 81%), and timber sale administration (T05, 97% to 90%). For all timber activities combined, problems associated with BMP implementation most frequently occurred during the layout and administrative phases of the projects (Table 6).

**TABLE 6: Phases during which problems occurred when BMPs were not implemented, Timber Management (1992-2002)[7].**

| Project Phase | TO1 | TO2 | TO4 | TO5 | TO6 | TO7 | All Timber |
|---|---|---|---|---|---|---|---|
| Site Evaluation | 9 | 10 | 11 | * | 0 | 0 | 30 |
| Plan Prescription | 8 | 6 | 8 | * | 0 | 1 | 23 |
| Environmental Analysis | 11 | 6 | 4 | * | 0 | 1 | 22 |
| Contract | 6 | 8 | 8 | 6 | 0 | 3 | 31 |
| Contact Modifications | * | * | * | 0 | * | * | 0 |
| Layout | 29 | 18 | 15 | 11 | 0 | 4 | 77 |
| Administration | 33 | 36 | 30 | * | 1 | 5 | 105 |
| Administration of Standard Operating Procedures | * | * | * | 29 | * | * | 29 |
| Post Sale | 7 | * | * | * | * | 1 | 8 |

* = Not applicable

[6] Special erosion control and revegetation (T06) is exluded from this discussion due to small sample size. Implementation rates and effectiveness rates were 100% for T06 based on seven samples.

[7] * = not applicable to this protocol

**FIGURES 8 & 9**

**FIGURE 10**

When implemented, timber BMPs were effective 94% of the time (Figure 9). Effectiveness rates during the first and second monitoring periods were approximately equal. Average effectiveness rates for individual evaluations ranged from 85% for SMZ protection (T01) to 98% for landings (T04), timber sale administration (T05), and meadow protection (T07) (Figure 9). All timber BMPs, except SMZ protection, had effectiveness rates above 95%. Between the two monitoring periods, effectiveness rates for skid trails (T02) increased moderately from 91% to 98%, but rates for SMZs (T01) decreased from 89% to 82%. No other substantial changes occurred. Considering all timber sites, including those where BMPs were and were not implemented, BMP effectiveness objectives were met 91**%** of the time from 1992 through 2002 (Figure 10). This ranged from 79% for SMZs (T01) to 99% for timber sale administration (T05). Based on their likely extent, duration, and/or magnitude, effects were classified as elevated at 20 (<2%) sites. These effects were typically associated with poor BMP implementation. No elevated effects have been observed since 1998. Details regarding individual timber BMPs are provided in the sections that follow.

#### 2.4.3.1. Streamside Management Zones (T01)

BMPs for SMZ protection were implemented 83% of the time from 1992 through 2002 (Figure 8). Implementation rates during the 1997-2002 monitoring period (80%) were somewhat lower than those from the 1992-1996 monitoring period (86%). At the 48 sites where these BMPs were not implemented, minor departures most commonly resulted from failures to follow SMZ width criteria (26)[8], adhere to SMZ prescriptions (26), and exclude mechanized equipment (22) (Table A-3). Major departures were most frequently caused by failures to treat the SMZ as prescribed (14) and to exclude mechanized equipment (13). Problems with implementation of SMZ BMPs occurred most often during the layout and administrative phases of projects (Table 6).

During the composite monitoring period, these BMPs were effective at 85% of the 230 sites at which they were implemented (Figure 9). These rates decreased from 89% to 82% between the first and second monitoring periods. Of all 278 sites evaluated, effectiveness objectives were met 79% of the time (Figure 10). At the 59 sites where these objectives were not met, minor departures were most common for streambank disturbance (24) and ground cover (19) criteria (Table A-4). Sediment discharge to the SMZ or stream channel was the criterion for which major departures were most frequent (38). Based on their likely extent, duration, and magnitude, effects were classified as elevated at seven (<3%) sites (Table 5). Four of these occurred during the most recent monitoring period, but none have been observed since 1998. Elevated effects at all seven sites were caused by inadequate BMP implementation. This included failure to properly identify and exclude equipment from watercourses and SMZs. Poor placement and construction of roads, stream crossings, and skid trails were also problematic.

[8] values in parenthesis are the number of occurrences

#### 2.4.3.2. Skid Trails (T02)

From 1992 through 2002, BMPs for skid trails were implemented at 84% of monitored sites (Figure 8). BMP implementation was moderately lower during the second monitoring period (81%) than the first (86%). At the 50 sites where these BMPs were not implemented, minor departures were most often due to poor location (19) and drainage and erosion control failures (24) (Table A-3). Major departures were also most frequently associated with these criteria (10 and 9 sites, respectively). Specifically, common causes of poor BMP implementation were the inadequate use of waterbars (number, location, construction), logging during wet periods, and placement of skid trails too close together or on steep slopes. Most implementation problems occurred during the layout and administrative phases of projects (Table 6).

When implemented, these BMPs were effective 95% of the time during the composite monitoring period (Figure 9). Effectiveness rates were moderately higher during the second monitoring period than the first (98% vs. 91%). Considering all 305 sites that were evaluated, effectiveness objectives for skid trail BMPs were met 92% of the time (Figure 10). At the 26 sites where these objectives were not met, erosion on skid trails (8) and below waterbars (8) comprised the greatest number of minor departures (Table A-4). The most frequent major departures were for skid trail surface erosion (12), sediment below waterbars (14), and sediment delivery to the SMZs or stream channels (12). Effects were classified as elevated at 5 (<2%) sites. Three of these were observed during the most recent monitoring period, but none have occurred since 1998. Elevated effects at four of the sites were caused by inadequate BMP implementation, including insufficient planning and environmental analysis and poor location (e.g., on steep slopes, near ephemeral channels) and construction (e.g., too few waterbars) of skid trails. Effects at one site, however, were ranked as elevated even though BMPs were implemented. This was due to high site sensitivity after a fire and public pressure that precluded SMZ treatments intended to increase ground cover.

#### 2.4.3.3. Suspended Yarding (T03)

BMP implementation and effectiveness was evaluated at 95 different suspended yarding sites from 1992 through 2002. No quantitative results are available for these activities due to the issues described in Tables 3 and A-1. Results from all of these evaluations will be analyzed and documented in future reports once ongoing database work is complete.

#### 2.4.3.4. Landings (T04)

BMPs for landings were implemented at 89% of the 420 sites monitored from 1992 through 2002 (Figure 8). Implementation rates were similar during the first and second monitoring periods. Minor departures at the 47 sites where these BMPs were not implemented most commonly resulted from inadequate drainage (32) (Table A-3). Major departures were most frequently related to landing location (6), drainage (4), and stabilization (4). Specifically, implementation problems were typically caused by locating new landings too close to watercourses or on unstable

areas or using existing landings with similar problems. Inadequate use of waterbars, failure to till landings after use, and poor groundcover also caused implementation failures. Most of these problems occurred during layout and administration (Table 6).

From 1992 through 2002, these BMPs were effective at 98% of the 373 sites at which they were implemented (Figure 9). These rates were not substantially different during the 1992-1996 and 1997-2002 monitoring periods. For all 420 sites, effectiveness objectives were met 95% of the time (Figure 10). At the 22 sites where these objectives were not met, minor departures were most frequently due to rilling or gullying below drainage structures (8) and rilling on fillslopes (6) (Table A-4). The most common major departures were sediment delivery to SMZs or stream channels (19) and rilling on the landing surface (12). Based on their likely magnitude, duration, and/or extent, effects were classified as elevated at seven (<2%) sites. Four of these occurred during the 1997-2002 monitoring period, but none have occurred since 1998. Effects at these seven sites were caused by poor placement of waterbars, insufficient rehabilitation (e.g., tillage, mulch), and placement of landings too close to watercourses.

#### 2.4.3.5. Timber Sale Administration (T05)

BMPs for timber sale administration (TSA) were implemented at 94% of the 67 sites monitored from 1992 through 2002 (Figure 8). Rates of implementation were moderately lower from 1997 through 2002 (90%) than from 1992 through 1996 (97%). Of the four instances where BMPs were not implemented, minor departures from erosion control requirements were found at two sites (Table A-3). Failure to implement erosion control requirements, maintain erosion control devices, and obtain approval for changes to decisions made during environmental analysis were the causes of major departures at two sites. Problems with implementation of TSA BMPs were most frequently associated with administration of Standard Operating Procedures (Table 6).

When implemented, these BMPs were effective 98% of the time from 1992 through 2002 and these rates did not change significantly between the 1992-1996 and 1997-2002 monitoring periods (Figure 9). Considering all 67 monitored sites, effectiveness objectives for these BMPs were met 99% of the time (Figure 10). A minor departure for wet weather operations and a major departure associated with sediment discharge to a SMZ or stream channel was found at the one site where these objectives were not met (Table A-4). No sites had effects classified as elevated (Table 5).

#### 2.4.3.6. Special Erosion Control and Revegetation (T06)

BMPs for special erosion control and revegetation were implemented and effective at all seven sites monitored in 2002 (Figures 8 and 9). Fifty-seven sites monitored between 1992 and 2001 were excluded from this report due to the issues described in Tables 3 and A-1. Upon completion of ongoing database modifications, analysis of these additional sites will provide more substantive results.

#### 2.4.3.7. Meadow Protection (T07)

BMPs for meadow protection were implemented at 93% of the 134 sites monitored from 1992 through 2002 (Figure 8). Implementation rates increased between the first (89%) and second (97%) monitoring periods. At the nine sites where these BMPs were not implemented, minor departures were most commonly associated with failure to exclude mechanical equipment (7) (Table A-3). Major departures were most frequently caused by failures to identify meadows on sale area maps (2). Implementation problems occurred primarily during the administrative phase of projects (Table 6).

From 1992 through 2002, these BMPs were effective at 98% of the sites at which they were implemented (Figure 9). Effectiveness rates did not change substantially between the first and second monitoring periods. Considering all 134 monitored sites, effectiveness objectives for meadow protection BMPs were met 96% of the time (Figure 10). Major departures from disturbance criteria were found at all six sites where these objectives were not met (Table A-4). Effects were classified as elevated at one (<1%) site evaluated in 1997 (Table 5). They were caused by a combination of poor BMP implementation associated with road construction, extreme site sensitivity, and a major storm event.

### 2.4.4. Engineering

From 1992 through 2002, implementation and effectiveness was evaluated at 1572 different randomly selected sites where engineering BMPs were to be applied. Because 108 in-channel construction practice (E13) evaluations and 25 pioneer road construction (E18) evaluations were excluded from this report for the reasons described earlier (Tables 3 and A-1), results described below are based on 1,439 of those sites.

On average, engineering BMPs were implemented 85% of the time during the composite monitoring period (Figure 11). Average implementation rates were similar during the 1992-1996 and 1997-2002 monitoring periods. For individual evaluations, average implementation rates during the composite monitoring period ranged from 71% for in-channel construction practices (E13) to 95% for servicing and refueling (E12) (Figure 11).[9] All BMPs, except those pertaining to control of sidecast material (E11), in-channel construction practices (E13), water source development (E16), and restoration of borrow pits and quarries (E19) had implementation rates greater than or equal to 85%. During the second monitoring period, implementation rates increased moderately to substantially for control of sidecast (E11, 75% to 84%), servicing and refueling (E12, 94% to 100%), rip rap composition (E15, 87% to 100%), water source development (E16, 74% to 86%), and protection of roads during wet periods (E20, 90% to 96%). Temporary road (E14) and snow removal (E17) BMPs had lower implementation rates during the second monitoring period, decreasing 6% and 17%, respectively. For all engineering activities combined, problems associated with BMP implementation most frequently occurred during the maintenance and administrative phases of the projects (Table 7).

[9] Pioneer road construction is omitted from discussion due to a sample size of one.

During the composite monitoring period, engineering BMPs were effective at 89% of the sites at which they were implemented (Figure 12). Effectiveness rates were similar during the first and second monitoring periods. Average effectiveness rates for individual evaluations varied from 69% for water source development (E16) to 100% for servicing and refueling (E12). All engineering BMPs were effective 88% of the time or more except those pertaining to water source development. Effectiveness rates increased for restoration of borrow pits and quarries (E19, 88% to 100%), but decreased for rip rap composition (E15, 92% to 83%) and water source development (E16, 78% to 58%). Effectiveness rates for the remaining practices were relatively unchanged between the two monitoring periods. Considering all 1,439 monitored sites, effectiveness objectives were met 84% of the time (Figure 13). Based on their likely magnitude, duration, and/or extent, effects were classified as elevated at 46 (<3%) sites. The number of engineering sites where elevated effects occurred was similar between the 1992-1996 and 1997-2002 monitoring periods for all engineering practices, except those associated with stream crossings. A substantially larger number of effects at these sites were ranked as elevated during the most recent monitoring period. Most of these were observed in 1997 or 1998 and were the result of increased failures associated with the large storms of 1997. Elevated effects were typically associated with poor BMP implementation. Details regarding individual engineering BMPs are provided in the sections that follow.

**TABLE 7: Phases during which problems occurred when BMPs were not implemented, Engineering BMPs (1992-2002).**

| Project Phase | E08 | E09 | E10 | E11 | E12 | E13 | E14 | E15 | E16 | E17 | E18 | E19 | E20 | All Engineering |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site Evaluation | * | * | 0 | 1 | 0 | 0 | 1 | 0 | 4 | 3 | 0 | 1 | 0 | 10 |
| Location | 8 | 5 | * | * | * | * | * | * | * | * | * | * | * | 13 |
| Design | 14 | 14 | * | * | * | * | * | * | * | * | * | * | * | 28 |
| Plan Prescription | * | * | 0 | 9 | 1 | 0 | 1 | 1 | 9 | 1 | 0 | 6 | 1 | 29 |
| Environmental Analysis | 7 | 7 | 0 | 6 | 1 | 1 | 0 | 0 | 7 | 3 | 1 | 2 | 0 | 35 |
| Contract | 5 | 6 | 1 | 10 | 1 | 1 | 6 | 0 | 3 | 2 | 0 | 3 | 1 | 39 |
| Layout | * | * | * | 2 | 0 | 0 | 2 | 1 | 3 | 2 | 0 | 0 | 0 | 10 |
| Construction | 14 | 17 | * | * | * | * | * | * | * | * | * | * | * | 31 |
| Maintenance | 25 | 23 | * | * | * | * | * | * | * | * | * | * | * | 48 |
| Administration | * | * | 3 | 19 | 2 | 4 | 10 | 2 | 8 | 19 | 0 | 11 | 3 | 82 |
| Follow-up Treatment | * | * | 0 | * | * | * | * | * | * | * | * | * | * | 0 |

**FIGURES 11 & 12**

# FIGURES 13

#### 2.4.4.1. Road Surface, Drainage, and Slope Protection (E08)

From 1992 through 2002, BMPs for road surface, drainage, and slope protection were implemented at 85% of the 284 sites evaluated (Figure 11). Implementation rates during the first and second monitoring periods were similar. At the 40 sites where these BMPs were not implemented, consistency of drainage structure repair with road management objectives was the criterion for which both minor (18) and major departures (8) were most common (Table A-5). Problems with implementation of these BMPs most frequently occurred during project design, construction, and maintenance (Table 7).

During the composite monitoring period, these BMPs were effective 90% of the time that they were implemented (Figure 12). These rates were not substantially different between the first and second monitoring periods. Considering all monitored sites, effectiveness objectives for road surface, drainage, and slope protection BMPs were met 83% of the time (Figure 13). At the 47 sites where effectiveness objectives were not met, minor departures were most frequently associated with rilling on road surfaces (15) and fillslopes (21) (Table A-6). Sediment discharges to SMZs or stream channels were the most common type of major departures (42). Effects were classified as elevated at 13 (<5%) sites, eight of which occurred during the most recent monitoring period. All eight of these were observed in 1997 or 1998 and were associated with the major storm events of 1997. Inadequate BMP implementation caused the elevated effects at all but one of these sites. Specifically, these effects were initiated by placement of sidecast into or near stream channels and failure to properly install culverts, ditches, or cross-drains. Lack of suitable road surfacing (i.e., rocking) and waterbars, blocked waterbar outlets, and poor road location were also problematic. Effects were considered elevated at one site even though BMPs were implemented. This was caused by the presence of highly erosive soils and the 1997 storm events.

#### 2.4.4.2. Stream Crossings (E09)

Stream crossing BMPs were implemented 85% of the time during the composite monitoring period (Figure 11). These rates did not change substantially between the first and second monitoring periods. At the 39 sites where these BMPs were not implemented, minor departures from drainage structure maintenance specifications were the most common (21) (Table A-5). Major departures were most frequently associated with failure to identify design objectives (5) and meet contract specifications for slope stabilization (5) and drainage (6). Problems with implementation of these BMPs occurred most often during the design, construction, and maintenance phases of the projects (Table 7).

From 1992 through 2002, these BMPs were effective at 88% of the sites at which they were implemented (Figure 12). Effectiveness rates were similar during the 1992-1996 and 1997-2002 monitoring periods. Considering all 304 sites, effectiveness objectives for stream crossing BMPs were met 80% of the time (Figure 13). At the 60 sites where these objectives were not met, minor departures were most frequently caused by a failure to meet vegetative cover requirements on fillslopes (23), puddling on road surfaces (15), erosion near drainage ditches (20), and plugging of culverts (15) (Table A-6). Major departures were most commonly caused by diversion potential (27), rilling of road surfaces (30), and rilling (26) and failure of fillslopes (25). Based on their likely extent, duration, and magnitude, effects were classified as elevated at 22 (6%) sites. Nineteen of

these occurred during the most recent monitoring period. Most of those were observed in 1997 or 1998. Effects were classified as elevated at only three sites monitored since 1998. Inadequate BMP implementation was the cause of elevated effects most of the 22 sites. Specifically, improper location of a culvert in a sensitive area, inadequate drainage, culvert installation below grade and out of alignment with the channel, poor road alignment, improper fill material, and lack of revegetation and slope stabilization were problematic. Large storm events and site sensitivity were cited as the cause at several sites where elevated effects occurred despite implementation of BMPs.

#### 2.4.4.3. Road Decommissioning (E10)

BMPs for road decommissioning were implemented at 87% of the 29 sites monitored since 2001, when this protocol was first applied (Figure 11). Of the four sites where BMPs were not implemented, minor departures from side slope configuration requirements were found at three sites (Table A-5). Major departures occurred once for fill excavation, channel configuration, and disposal area criteria. Specific causes of poor implementation included inadequate site excavation, poor road closures, unclear contract language, and failure to include an earth scientist in project review, design, and implementation. Problems most frequently occurred during the administrative phase of projects (Table 7).

During the composite monitoring period, these BMPs were effective at 93% of the sites at which they were implemented (Figure 12). Considering all 29 sites, effectiveness objectives for these BMPs were met 89% of the time (Figure 13). At the three sites where these objectives were not met, minor departures from road surface rilling and channel reconfiguration were each found once (Table A-6). Major departures were found one time for traffic control, channel adjustment, slope failure, and side slope rilling criteria. No sites had effects classified as elevated.

#### 2.4.4.4. Control of Sidecast Material (E11)

BMPs for control of sidecast material were implemented 79% of the time during the composite monitoring period (Figure 11). Implementation rates increased between the first and second monitoring periods, from 75% to 84%. Minor departures from requirements to limit sidecasting in plans and to designate disposal areas were found at 32 of the 45 sites where these BMPs were not implemented (Table A-5). Minor departures from requirements to limit sidecast were found at all of these sites. No major departures from any implementation criteria were found. Problems most frequently occurred during the contract and administrative phases of projects (Table 7). Specifically, incorporating sidecast requirements from environmental documents into contracts was found to be problematic.

From 1992 through 2002, these BMPs were effective 95% of the time that they were implemented (Figure 12). These rates did not change between the first and second monitoring periods. Effectiveness objectives for BMPs related to control of sidecast material were met at 88% of all 209 sites observed during the composite monitoring period (Figure 13). At the 25 sites where these objectives were not met, most minor departures were associated with placement of sidecast in an SMZ (14) or near a stream channel (10) (Table A-6). Deposition of sidecast on stream crossing fills (16) or near stream channels (15) or ditches (13) were the most common types of major departures.

Effects were classified as elevated at one site (<1%) evaluated during the first monitoring period. This was caused by poor BMP implementation, specifically the placement of large amounts of sidecast less than 10 feet from a stream.

#### 2.4.4.5. Servicing and Refueling (E12)

From 1992 through 2002, BMPs for servicing and refueling were implemented 95% of the time (Figure 11). Implementation rates increased from 94% during the first monitoring period to 100% during the second. At the two sites where BMPs were not implemented, minor departures from requirements to develop a spill prevention plan and to properly locate a storage area were found once each (Table A-5). A major departure was found once for failure to meet storage area requirements and to construct spill containment devices. Due to a small sample size, problems were not evident in any particular phase of projects.

From 1992 through 2002, these BMPs were effective at 100% of the sites at which they were implemented (Figure 12). Effectiveness objectives for servicing and refueling BMPs were met at 98% of all 42 monitored sites (Figure 13). A major departure occurred at one site, where there was evidence of discharge within 50 feet of a waterway (Table A-6). No effects on beneficial uses were observed (Table 5).

#### 2.4.4.6. In-channel Construction Practices (E13)

Due to the issues described in Tables 3 and A-1, only 2002 data for E13 could be analyzed quantitatively. The 1992-2001 data was analyzed qualitatively to assess performance during that time period. This assessment was based on responses to individual implementation and effectiveness questions at all monitored sites.

<u>2002 Data</u>

BMPs for in-channel construction were implemented at 71% of the 24 sites monitored in 2002 (Figure 11). Minor departures at the seven sites where BMPs were not implementation were most often the result of improper management of excavated materials (5) and failure to restore the channel (3) (Table A-5). A major departure related to implementation of requirements for diverting flow around construction sites was noted at one site. Most problems occurred during the administrative phase of projects (Table 7).

When implemented, these BMPs were effective at 88% of the sites monitored in 2002. Considering all 24 sites, effectiveness objectives for these BMPs were met 79% of the time (Figure 13). At the five sites where these objectives were not met, a minor departure occurred once due to fill on the floodplain (Table A-6). Major departures were associated with changes in channel riffle substrate (2) and turbidity plumes below crossing sites (2).

1992-2001 Data

From 1992 through 2001, most of the 108 sites either met or exceeded the implementation and effectiveness criteria, or these criteria did not apply (Tables A-7 and A-8). Consequently, no major problems appear evident during those years.

Effects were classified for all sites monitored from 1992 through 2002. Effects were elevated at three (2%) of the 132 sites. All of these were caused by poor implementation of BMPs, including failure to revegetate exposed soils, dewater sites, and consult an earth scientist.

#### 2.4.4.7. Temporary Roads (E14)

BMPs for temporary roads were implemented 91% of the time during the composite monitoring period (Figure 11). Implementation rates were lower during the second monitoring period (88%) than the first (94%). At the 12 sites where BMPs were not implemented, minor departures were most commonly associated with drainage (5) and road closure requirements (5) (Table A-5). Major departures were most often related to road closure requirements (6). The majority of problems occurred during the administrative phase of projects (Table 7).

Between 1992 and 2002, these BMPs were effective at 90% of the sites where they were implemented (Figure 12). These rates did not change considerably between the two monitoring periods. Effectiveness objectives for temporary road BMPs were met at 87% of all 133 monitored sites (Figure 13). At the 17 sites these objectives were not met, minor departures were most commonly associated with road surface rilling (4) (Table A-6). Major departures were related to sediment delivery to or near a stream channel (4). Two sites had effects classified as elevated due to their extent, duration, and/or magnitude. Both of these occurred during the first monitoring period. Effects at both sites were caused by insufficient BMP implementation, specifically the failure to obliterate roads as specified in the contract and lack of stabilization and drainage for a stream crossing.

#### 2.4.4.8. Rip Rap Composition (E15)

Rip rap BMPs were implemented at 92% of the 25 sites evaluated from 1992 through 2002 (Figure 11). Only two sites had poor BMP implementation. Implementation rates increased from 87% from 1992 through 1996 to 100% from 1997 through 2002. Minor departures from requirements that rip rap be free from organic and other non-structural materials occurred at both sites (Table A-5). Major departures occurred once for failure to use specified rip rap material and once for failure to place it as prescribed. Most problems occurred during the administrative phase of projects (Table 7).

When implemented, these BMPs were effective 89% of the time during the composite monitoring period (Figure 12). Effectiveness rates decreased from 92% during the first monitoring period to 83% during the second. Considering all 25 monitored sites, effectiveness objectives for rip rap BMPs were met at 84% of the time (Figure 13). No minor departures from individual effectiveness criteria occurred at the four sites where effectiveness objectives were not met (Table A-6). Major departures from scour criteria occurred at each of these four sites. No elevated effects on water quality were observed (Table 5).

#### 2.4.4.9. Water Source Development (E16)

BMPs for water source development were implemented 79% of the time from 1992 through 2002 (Figure 11). Implementation rates increased from 74% to 86% between the 1992-1996 and 1997-2002 monitoring periods. At the 16 sites where these BMPs were not implemented, minor and major departures were most frequently associated with failure to include water quality protection measures in project plans (eight and four occurrences, respectively). Problems most frequently occurred during plan prescription, environmental analysis, and administrative phases of projects (Table 7).

These BMPs were effective 69% of the time that they were implemented during the composite monitoring period (Figure 12). Effectiveness rates decreased from 78% to 58% between the first and second monitoring periods. Considering all 78 sites observed from 1992 through 2002, effectiveness objectives for water source development were met 64% of the time (Figure 13). At the 28 sites where these objectives were not met, there were no minor departures from any individual effectiveness criteria (Table A-6). Major departures were most often associated with evidence of rilling into streams (22). Based on comments from field evaluators, adjacent roads and stream crossings appear to be the cause of poor effectiveness in many cases. Effects were classified as elevated at two sites (<3%) sites, one during each of the two monitoring periods. Effects at one of these sites were caused by a lack of BMP implementation, specifically failure to provide adequate soil cover. Heavy cattle use caused elevated effects at the site where BMPs were implemented.

#### 2.4.4.10. Snow Removal (E17)

BMPs for snow removal were implemented 86% of the time from 1992 through 2002 (Figure 11). Implementation rates were considerably different between the 1992-1996 and 1997-2002 monitoring periods, decreasing from 94% to 77%. Of the 26 sites where BMPs were not implemented, minor and major departures occurred most often when snow removal standards in a contract or forest policy were not met (20 and six occurrences, respectively) (Table A-5). Specific problems included removal of the road surface during plowing, poor drainage due to lack of breaks in snow banks, plowing when the ground was too wet, and lack of an established prescription. Administrative phases of these activities were most problematic (Table 7).

During the composite monitoring period, these BMPs were effective 88% of the time that they were implemented (Figure 12). Effectiveness rates were relatively similar during the first and second monitoring periods. Considering all 180 sites monitored, effectiveness objectives for snow removal BMPs were met at 86% of the time (Figure 13). At the 25 sites where these objectives were not met, road surface rutting caused the most minor departures (17) (Table A-6). Major departures were related to sediment delivery to an SMZ or stream channel (24). No sites had effects categorized as elevated.

#### 2.4.4.11. Pioneer Road Construction (E18)

BMPs for pioneer road construction were implemented and effective at the one site monitored in 2002 (Figures 11 and 12). No effects on beneficial uses were observed. This activity is relatively uncommon in the Region, so it is not possible to obtain large sample sizes. Twenty-five sites monitored between 1992 and 2001 were excluded from this analysis due to the issues

described in Tables 3 and A-1. Upon completion of planned database work, analysis of these additional sites will provide more substantive results.

#### 2.4.4.12. Restoration of Borrow Pits and Quarries (E19)

BMPs for restoration of borrow pits and quarries were implemented 77% of the time during the composite monitoring period (Figure 11). Results were not significantly different during the first and second monitoring periods. At the 15 sites where these BMPs were not implemented, minor and major departures resulted most often from a failure to treat the land surface as specified (six and nine occurrences, respectively) (Table A-5). Problems occurred most frequently during the administrative phase of projects (Table 7). Based on database comments, the lack of restoration plans for these areas was also problematic.

From 1992 through 2002, these BMPs were effective at 90% of the sites at which they were implemented (Figure 12). Effectiveness rates increased from 88% during the first monitoring period to 100% during the second. Considering all 64 monitored sites, effectiveness objectives were met 80% of the time (Figure 13). At the 13 sites where these objectives were not met, minor departures were most often associated with sediment delivery from work areas to SMZs or stream channels (3) (Table A-6). Major departures were most commonly the result of failure to meet road cover requirements (12), erosion below excavations (11), and sediment delivery to SMZs or stream channels (11). Effects were classified as elevated at two (3%) sites, both of which occurred during the first monitoring period. These effects were caused by poor BMP implementation, specifically the failure to stockpile soil and rip, seed, or mulch a site.

#### 2.4.4.13. Management of Roads During Wet Periods (E20)

During the composite monitoring period, BMPs for managing roads during wet periods were implemented 92% of the time (Figure 11). These rates were slightly higher during the most recent monitoring period (96% vs. 90%). Failure to install closures as specified was the most common cause of minor departures (4) at the five sites where these BMPs were not implemented (Table A-5). Major departures occurred once for failure to close roads as specified and implement wet weather operations policies. Administrative phases of this activity were most problematic (Table 7).

When implemented, these BMPs were effective 89% of the time during the composite monitoring period (Figure 12). Effectiveness rates did not change between the two monitoring periods. Considering all 66 sites, effectiveness objectives were met 86% of time. At the nine sites where these objectives were not met, minor departures were most commonly associated with road surface rutting (3) (Table A-6). Rilling (4) and sediment delivery (8) to channels were the most frequent causes of major departures. No sites had effects ranked as elevated due to their extent, duration, and/or magnitude.

### 2.4.5. Recreation

BMP implementation and effectiveness was evaluated at 222 randomly selected recreation sites from 1992 through 2002. Results described below are based 176 of those sites because 46 evaluations for location of stock facilities in the wilderness (R23) were excluded for the reasons discussed previously (Tables 3 and A-1). Thirty-four of the 176 sites were analyzed quantitatively and the remaining 142 sites were qualitatively evaluated. Once ongoing database work is complete, inclusion of the additional R23 evaluations will provide more substantive results.

Recreation BMPs were implemented at 68% of the 34 sites analyzed quantitatively (Figure 14). Problems associated with BMP implementation at these sites occurred most frequently during the layout and administrative phases of the projects (Table 8). BMPs were effective at 89% of the sites at which they were implemented (Figure 15). Considering all 34 sites, effectiveness objectives were met 74% of the time (Figure 16).

Effects were classified for all 176 sites, whether they were analyzed quantitatively or qualitatively, based on their likely extent, duration, and/or magnitude. Elevated effects occurred at four (2%) of these sites.

**TABLE 8: Phases during which problems occurred when BMPs were not implemented, Recreation.**

| Project Phase | R22 | R30 | All Recreation |
|---|---|---|---|
| Site Evaluation | 1 | 0 | 1 |
| Plan Prescription | 0 | 0 | 0 |
| Environmental Analysis | 0 | 0 | 0 |
| Permit/Operating Plan | * | * | 0 |
| Contract | 0 | 0 | 0 |
| Layout | 0 | 6 | 6 |
| Administration | 1 | 4 | 5 |

#### 2.4.5.1. Developed Recreation Sites (R22)

Only 2002 data for R22 could be analyzed quantitatively because of the issues described in Tables 3 and A-1. Consequently, the 1992-2001 data were analyzed qualitatively to evaluate performance during that time period. This evaluation was based on responses to individual implementation and effectiveness questions.

<u>2002 data</u>

BMPs for developed recreation sites were implemented 83% of the time in 2002 (Figure 14). At the three sites where BMPs were not implemented, minor departures were found once for washing within 100 feet of water and failure to meet SMZ protection, runoff control, and ground cover requirements (Table A-9). Only one major departure occurred. This was caused by a failure to provide adequate runoff control from impervious surfaces. No project phases were more problematic than others (Table 8).

**FIGURES 14 & 15**

**FIGURE 16**

These BMPs were effective at 80% of the sites at which they were implemented (Figure 15). Considering all 18 observation sites, effectiveness objectives were met 67% of the time (Figure 16). At the six sites where these objectives were not met, minor departures were most common for sediment delivery to stream channels (4) and ground cover criteria (3). Major departures occurred only once for failure to control runoff (Table A-10).

1992-2001 data

Tables A-11 and A-12 display the frequencies of responses to individual implementation and effectiveness questions at the 142 sites monitored between 1992 and 2001. At the majority of sites, most of the implementation criteria were met or did not apply. However, minor and major departures from requirements to keep substances that could degrade water quality greater than 100 feet away from watercourse occurred at 69% and 20% of sites, respectively. There also appear to be some effectiveness problems, since major departures associated with cleaning or washing at hydrants and faucets and sediment delivery to stream channels were found at 18% and 21% of sites, respectively. Many developed recreation sites were sited and developed prior to formal adoption of BMPs. This may be a cause of some of the problems noted above.

Effects were classified for all 160 sites, whether they were analyzed quantitatively or qualitatively. Elevated effects were observed at four (<3%) sites, three of which occurred during the 1992-1996 monitoring period. Elevated effects were caused by poorly maintained roads at three sites and heavy foot traffic at one site.

#### 2.4.5.2. Location of Stock Facilities in the Wilderness (R23)

Data from this evaluation have been excluded from this report for the reasons described in Tables 3 and A-1. This data will be quantitatively analyzed and reported once ongoing database work is completed.

#### 2.4.5.3. Dispersed Recreation Sites (R30)

BMPs for dispersed recreation sites were implemented 50% of the time since this protocol was first applied in 1999 (Figure 14). At the eight sites where BMPs were not implemented, minor departures most commonly resulted from failures to meet refuse disposal (5) and ground cover criteria (6) and provide SMZ protection (5)(Table A-9). Major departures occurred once for sanitation facilities and groundcover criteria and once for failure to visit the site to evaluate water quality impacts. Problems with implementation of these BMPs occurred most frequently during the layout and administrative phases of projects (Table 8).

These BMPs were effective at 100% of the sites at which they were implemented (Figure 15). Considering all 16 monitored sites, effectiveness objectives for these BMPs were met 81% of time (Figure 16). At the three sites where these objectives were not met, major departures were found for water quality degradation from human waste, animal waste, or sediment (Table A-10). No sites had effects that were classified as elevated due to their extent, duration, and/or magnitude (Table 5).

### 2.4.6. Grazing

From 1992 through 2002, BMP implementation and effectiveness was evaluated at 152 different grazing sites. Due to the issues described in Tables 3 and A-1, no quantitative results are currently available for this activity. The monitoring protocol was revised in 2001 to address these issues and pilot testing of the draft revisions began in 2002. This pilot testing identified other concerns that need to be resolved before the protocol is finalized. Resolution of these issues and completion and implementation of the revised protocol is scheduled for 2005 or 2006.

Despite these problems, qualitative analysis of results from the 1992-2001 monitoring was possible. Based on responses to individual implementation and effectiveness questions (Table A-13), there were modest problems with implementation of these BMPs. No sites had major departures for any of the individual implementation criteria, but a large percentage of sites had minor departures from requirements to conduct site-specific range analyses (70%) and stock counts (50%). Attaining effectiveness criteria was less successful (Table A-14). Major departures from streambank disturbance criteria, for example, occurred at 18% of sites and minor departures occurred at 48% of sites. While these data indicate that streambank disturbance associated with grazing warrants continued attention, they should be viewed with caution because the methods used to obtain the data have since been determined to provide inconsistent results. Achieving riparian ground cover objectives was also problematic, with major and minor departures present at 11% and 25% of sites, respectively. However, caution is also warranted in applying these results, because they are inconsistent with those of Weixelman (2003).

Effects were classified as elevated at five (<4%) sites, three of which occurred during the second monitoring period. Based on comments from field observers, these effects appear to have been caused by a lack of adequate BMP implementation. Specifically, they resulted from exceeding the number of allowable cattle on an allotment, salting too close to water, inadequate monitoring of cattle, and excessive streambank trampling from grazing a site too long.

### 2.4.7. Prescribed Fire

BMPs for prescribed fire (F25) were implemented 77% of the 250 sites evaluated during the composite monitoring period (Figure 17). Implementation rates fell from 79% to 74% between the first and second monitoring periods. Problems with implementation of these BMPs occurred most frequently during development of the burn prescription and the burn itself (Table 9). At the 59 sites where BMPs were not implemented, minor and major departures from requirements to consider water quality protection measures in the burn plan prescription and to implement those measures occurred with similar frequencies (Table A-15).

**FIGURES 17 & 18**

**FIGURE 19**

**TABLE 9: Phases during which problems occurred when BMPs were not implemented, Prescribed Fire.**

| Project Phase | F25 |
|---|---|
| Site Evaluation | 0 |
| Burn Prescription | 27 |
| Burn | 23 |
| Mop up | 1 |
| Patrol | 0 |

From 1992 through 2002, these BMPs were effective at 98% of the sites at which they were implemented (Figure 18). Effectiveness rates were relatively similar during the 1992-1996 and 1997-2002 monitoring periods. Considering all 254 observation sites, effectiveness objectives for prescribed fire BMPs were met 96% of the time (Figure 19). At the 10 sites where these objectives were not met, minor departures were most common for hydrophobic soils (4) and upslope rilling (3) criteria (Table A-16). Sediment discharge to the channel (6), upslope rilling (6) and upslope ground cover (7) were the criteria for which major departures were most frequent. Based on their extent, duration, and/or magnitude, effects were classified as elevated at one (<1%) site. These effects were caused by inadequate BMP implementation, specifically the failure to provide adequate ground cover on a project in 1997.

### 2.4.8. Mining

BMP implementation and effectiveness was evaluated at 181 different mining sites from 1992 through 2002. No quantitative results are available for these activities due to the issues described in Tables 3 and A-1. However, quantitative results from eight M26 evaluations conducted in 2002 and all 93 M27 evaluations will be reported once ongoing database work is complete. Results from a qualitative analysis of the M26 data collected from 1992 through 2001 is provided below.

#### 2.4.8.1. Mining Operations, Locatable Minerals (M26)

Individual implementation criteria were met or exceeded at most sites monitored from 1992 through 2001, or these criteria did not apply (Table A-17). Major departures were found at 5% to 8% of sites, depending on the criterion. Implementing required erosion control work and completing this work prior to the wet season were most problematic. Major or minor departures from individual effectiveness criteria were found at a relatively high percentage of sites (Table A-18). Major departures associated with erosion and sediment delivery to streams from dumps, excavations, and fillslopes were most problematic, occurring at 15%-19% of monitored sites. Effects were considered elevated at one (1%) site (Table 5) that was observed during the first monitoring period. These effects were caused by inadequate BMP implementation, specifically the lack of environmental analysis and operating plans.

#### 2.4.8.2. Common Variety Minerals (M27)

Once ongoing database work is complete, all results for M27 will be quantitatively analyzed and presented in subsequent reports.

### 2.4.9. Vegetation Management

BMP implementation and effectiveness evaluations were conducted at 188 randomly selected sites where vegetation management activities had occurred from 1992 through 2002. On average, these BMPs were implemented 87% of the time (Figure 20). Implementation rates increased from 84% to 91% between the first and second monitoring periods. For all vegetation management activities combined, problems associated with BMP implementation most frequently occurred during the administrative phases of projects (Table 10).

During the composite monitoring period, these BMPs were effective 89% of the time that they were implemented (Figure 21). Effectiveness rates were relatively similar between the first and second monitoring periods. Considering all 188 sites, effectiveness objectives were met 87% of the time (Figure 22). Due to their extent, duration, and/or magnitude, effects were classified as elevated at one (<1%) site. Details regarding individual vegetation management BMPs are provided in the sections that follow.

**TABLE 10: Phases during which problems occurred when BMPs were not implemented, Vegetation Management.**

| Project Phase | V28 | V29 | All Vegetation Management |
|---|---|---|---|
| Site Evaluation | 0 | 2 | 2 |
| Plan Prescription | 1 | 1 | 2 |
| Environmental Analysis | 5 | 1 | 6 |
| Contract | 4 | 2 | 2 |
| Layout | 1 | 2 | 3 |
| Administration | 4 | 10 | 14 |

#### 2.4.9.1. Vegetation Manipulation (V28)

From 1992 through 2002, BMPs for vegetation manipulation were implemented 90% of the time (Figure 20). Implementation rates were similar between the 1992-1996 and 1997-2002 monitoring periods. At the 10 sites where BMPs were not implemented, minor departures most commonly resulted from failures to include in the project plan or contract the soil and water quality protection measures identified in environmental documents (3) and failure to implement these provisions as prescribed (3) (Table A-19). Major departures were most often related to failures to identify soil and water quality protection measures in environmental documents (5), failure to include these in project plans or contracts (4), and failure to apply treatments to prescribed areas (4). Problems with implementation of these BMPs most commonly occurred during the environmental analysis, contract, and administrative phases of projects (Table 10).

**FIGURES 20 & 21**

**FIGURE 22**

When implemented, these BMPs were effective 98% of the time during the composite monitoring period (Figure 21). Effectiveness rates were similar during the first and second monitoring periods. Considering all 99 sites, effectiveness objectives were met 96% of the time (Figure 22). At the four sites where these objectives were not met, minor departures were most common for rilling criteria (2) (Table A-20). Major departures were most often related to sediment discharge to a stream channel (3) and failure to meet ground cover objectives (3). No effects were classified as elevated due to their magnitude, extent, and/or duration (Table 5).

#### 2.4.9.2. Revegetation of Surface Disturbed Areas (V29)

BMPs for revegetation of surface disturbed areas were implemented 84% of the time from 1992 through 2002 (Figure 20). Between the first and second monitoring periods, these rates increased from 80% to 93%. Minor and major departures at the 15 sites where BMPs were not implemented were most often caused by failures to implement the revegetation requirements specified in environmental documents (nine and three occurrences, respectively) (Table A-19). Administrative phases of projects were most problematic (Table 10).

When implemented, these BMPs were effective 80% of the time during the 1992-2002 monitoring period (Figure 21). These rates were relatively similar during the 1992-1996 and 1997-2002 monitoring periods. Considering all 89 sites, effectiveness objectives were met 78% of the time (Figure 22). At the 20 sites where these objectives were not met, minor departures were most common for soil surface cover criteria (7) and sediment delivery to stream channels (6) (Table A-20). Major departures were most common for the same criteria (10 and 14, respectively). Effects were considered elevated at one (1%) site, which was observed during the 1992-1996 monitoring period. These effects were caused by pre-existing erosion problems that the project was unable to address.

## *2.5. Discussion, Issues, and Corrective Actions*

### 2.5.1. Program Management

While some improvements are necessary, overall, the USFS Region 5 water quality management program performed reasonably well during the 1992-2002 monitoring period and improvements have been made in recent years. BMP implementation and effectiveness were fairly high for most activities and elevated effects on water quality and beneficial uses of water were relatively infrequent. In addition, both the BMPs and the BMPEP have been expanded and improved since monitoring results were last reported in 1998. Specifically, the Region's BMPs were updated in 2000 based on an interdisciplinary review comprised of staff from the USFS Regional Office and forests, the SWRCB, and various Regional Water Quality Control Boards (RWQCBs). There have also been considerable improvements to the BMPEP, including the addition of protocols for road decommissioning and dispersed recreation, enhancements to existing protocols, and database upgrades.

While monitoring declined throughout the Region in 2000, it rebounded in 2001 and 2002 due to increased emphasis on this program from the Regional Forester, the Regional Leadership Team (Regional Forester, Deputy Regional Foresters, Regional Staff Directors, and Forest Supervisors), Forest Resource Staff Officers, and Forest Hydrologists. Monitoring results indicate that there is a statistically significant relationship between BMP implementation and effectiveness for 16 of the 29 monitoring protocols. An increase in the number of protocols with a demonstrated statistical relationship is expected once ongoing database modifications are complete.

For all activities combined, BMPs were implemented 85% of the time from 1992 through 2002 and were effective at 92% of the sites at which they were implemented. There were no major differences in implementation and effectiveness rates between the first and second monitoring periods. BMP implementation rates were 85% or higher for all functional areas except recreation and prescribed fire, which were 68% and 77%, respectively. They were 80% or higher for all but four forests and 75% or greater for all but one Forest. BMP effectiveness rates were 89% or greater for all functional areas. All forests had effectiveness rates of 82% or higher and 13 forests had rates of 90% or greater.

From 1992 through 2002, there were relatively few sites (78, 2%) where effects on water quality were classified as elevated due to their magnitude, extent, and/or duration. Most of these were associated with engineering practices (46, <3% of engineering sites). Consistent with published research (e.g., Gucinski 2001) and other related monitoring programs (e.g., CDF 2002), roads were the most problematic. This was particularly true for those activities near or connected to watercourses (e.g., stream crossings). Twenty of the elevated effects were associated with timber (<2% of timber sites), four were observed at recreation sites (<3%), and one was caused by a prescribed fire (<1%). One was observed at a mine (1%), one occurred at a vegetation management site (<1%), and five were related to grazing (<4%).

Actions needed to maintain and improve this level of performance are described in Tables 11-17.

**TABLE 11: Issues and Corrective Actions, Program Management**

| P-1 | |
|---|---|
| Issue | With the recent recovery since 2000, the amount of BMP monitoring being conducted meets expectations at a Regional scale. Ongoing emphasis on the program is needed to ensure these improvements are maintained. Analysis and reporting of monitoring results from the Regional Office and some forests has not met expectations described in the Management Agency Agreement (MAA) between the Forest Service and the SWRCB. This is necessary to ensure timely identification and correction of water quality problems. |
| Corrective Action | The Regional Office and forests will monitor, analyze, and report results consistent with the MAA. The Regional Office will provide this direction to forests via the FY 2005 budget direction and additional memoranda, as needed. |
| Status | FY 2005 budget direction will be provided when Congress approves the 2005 budget appropriation. |

| | |
|---|---|
| Priority | 1 |
| **P-2** | |
| Issue | The BMPEP was developed by interdisciplinary teams from the Forest Service with extensive input from regulatory agencies, industry, environmental groups, and other interested parties. However, the program has never been externally peer-reviewed. A peer review is desirable because: 1) RWQCB staffs have requested it to determine whether there are any program deficiencies; and 2) the Forest Service plans to begin implementing this monitoring program nationally and it would be beneficial to identify needed improvements before this occurs. |
| Corrective Action | The Regional Office will conduct an external peer-review of the BMPEP and incorporate changes as appropriate. |
| Status | In September 2004, the Regional Office signed a contract with Dr. Lee MacDonald from Colorado State University to peer review the BMPEP. A final report is expected in January 2006. The BMPEP will be modified thereafter, as needed. |
| Priority | 1 |
| **P-3** | |
| Issue | Periodic training for all staff areas is needed to ensure BMPs are implemented and effective. |
| Corrective Action | Forests will develop and implement routine BMP training. The Angeles, Plumas, Shasta-Trinity, and Tahoe national forests will place particular emphasis on this training since BMP implementation rates on these forests were lower than 80% during the 1992-2002 monitoring period. |
| Status | BMP training will occur on each Forest by the end of 2006. |
| Priority | 1 |
| **P-4** | |
| Issue | There is a potential for inconsistent implementation of the BMP monitoring program due to staff turnover and protocol changes. |
| Corrective Action | The Regional Office and forests will develop and implement an interdisciplinary training and Quality Assurance (QA)/Quality Control (QC) program for BMP monitoring, including application of the protocols and field forms and use of the BMPEP database. |
| Status | Three training sessions on use of the new BMPEP database were held between May and July 2003. The Region will develop a training and QA/QC program in 2005 and begin its implementation in 2006. |
| Priority | 1 |

| P-5 | |
|---|---|
| Issue | Despite significant improvements to the BMPEP database, additional work is needed. This work will allow for eventual quantitative analysis of some of the data excluded from this report (Tables 3 and A-1). |
| Corrective Action | The Regional Office will implement needed database work and subsequently report results associated with the data excluded from this report. |
| Status | Additional database work was initiated in 2003 and will be completed in early 2005. Results associated with these data will be included in future reports. |
| Priority | 1 |
| **P-6** | |
| Issue | Without a standard method for evaluating the implementation and effectiveness of off-highway vehicles (OHV) BMPs, it is not possible to evaluate the performance of OHV program at a Regional scale. |
| Corrective Action | The Regional Office and forests will develop and implement a standard OHV monitoring protocol. |
| Status | A draft protocol was developed and initial field tests were conducted in summer 2004. The protocol is currently being modified based on results from those tests and final field tests will be conducted in 2005. Regional implementation of the final protocol will begin in 2006. Database modifications to accommodate the new protocol will be made in 2005 or 2006. |
| Priority | 1 |
| **P-7** | |
| Issue | The protocol for grazing was significantly modified in 2001 to address previously identified shortcomings. Nonetheless, additional concerns were identified during pilot testing and discussions with other resource specialists. Consequently, the new protocol not been finalized and implemented. |
| Corrective Action | The Regional Office will complete the revision of this protocol based on the pilot testing. Once the revision is complete, forests will implement the new protocol. |
| Status | The revised protocol will be finalized in 2005. Implementation will begin in 2005 or 2006. |
| Priority | 1 |
| **P-8** | |
| Issue | The SWRCB and RWQCBs have expressed a desire for monitoring programs beyond the existing Onsite Evaluations (“hillslope monitoring”). |
| Corrective Action | The Regional Office and forests will implement monitoring programs to compliment the BMPEP Onsite Evaluations as issues arise and funding permits. |
| Status | As described in Section 3 of this report, several other monitoring projects and programs, including stream monitoring, have been implemented throughout the Region to compliment the BMPEP Onsite Evaluations. Together, these additional |

| | |
|---|---|
| | programs address a range of monitoring issues including validation of BMP effectiveness, compliance with regulatory standards, assessment of conditions and trends in water quality and aquatic resources, and development and validation cumulative watershed effects (CWE) models. |
| Priority | 2 |
| **P-9** | |
| Issue | Inability to complete crossing reconstruction work within the normal operating season and failure to account for wet-weather (fall-spring) erosion control measures during project planning on the Shasta-Trinity National Forest resulted in issuance of a Clean Up and Abatement Order (No. 99-77) in Fall 1999. Although limited impairment to beneficial uses of water were observed during subsequent monitoring, notable problems associated with meeting the SWRCB/USFS Management Agency Agreement surfaced as a direct result of this project. They included: (1) communication barriers between the USFS and the North Coast Regional Water Quality Control Board (Regional Board); (2) lack of full inclusion of BMPs into project design and contracts; and (3) insufficient interdisciplinary awareness of the USFS's responsibilities as a Water Quality Management Agency. |
| Corrective Action | a) National forests in the North Coast Region (Mendocino, Shasta-Trinity, Klamath, Six Rivers, and Modoc) and the North Coast RWQCB developed and are implementing an Interagency Action Plan to address these issues.<br><br>b) The Shasta-Trinity National Forest complied with the Clean Up and Abatement Order (No. 99-77) and Time Schedule Order No. R1-2000-21. |
| Status | a) The Action Plan continues to be implemented with positive results, including improved relationships between the North Coast RWQCB and USFS and strengthened water quality programs on the national forests in the North Coast Region.<br><br>b) The Shasta-Trinity National Forest complied with the Clean Up and Abatement Order (No. 99-77) and Time Schedule Order No. R1-2000-21. |
| Priority | 1 |
| | |

### 2.5.2. Timber Management

Overall, the timber program performed well during the 1992-2002 monitoring period. Implementation and effectiveness rates were relatively high (87% and 94%, respectively). Relatively few timber sites (20, <2%) had water quality effects rated as elevated and none of these effects were observed after 1998. Nonetheless, improvement is needed in some areas. Specifically, overall implementation rates fell from 89% during the first monitoring period to 85% during the second. These decreases were primarily caused by decreases in implementation rates for SMZs (T01) and skid trails (T02). While implementation rates for timber sale administration (T05) also decreased, these are not of significant concern because they were based on a relatively small sample size and implementation rates for these BMPs remain high. Additional details are provided in Table 12.

**TABLE 12: Issues and Corrective Actions, Timber Management**

| **T-1** | |
|---|---|
| Issue | While BMP implementation rates for SMZs (83%) were not particularly problematic during the composite monitoring period, they decreased from 86% to 80% between the first and second monitoring periods. In addition, effectiveness rates decreased from 89% to 82%. This raises some concerns, since proper management of SMZs is one of the most important aspects of water quality protection. |
| Corrective Action | a) Through a variety of means (e.g., formal direction, program reviews, site visits, annual meetings), the Regional Office will direct Timber Sale Administrators to emphasize these BMPs, particularly during layout and administration. Earth Scientists will focus on these BMPs during the timber sale planning and contract development process and use the results presented in this report to improve performance. To enhance BMP implementation, forests will concentrate on following SMZ width criteria, adhering to SMZ prescriptions, and excluding mechanical equipment. Forests will focus on limiting streambank disturbance and meeting ground cover objectives to enhance BMP effectiveness.<br><br>b) Forests will emphasize these practices during their BMP training sessions.<br><br>c) More monitoring will be focused on this activity.<br><br>d) Forests will continue to comply with the recently adopted RWQCB timber harvest waivers. This is expected to improve BMP implementation for this activity, since the waivers require interdisciplinary review of projects. |
| Status | a) Timber program reviews were conducted on six national forests in 2004. Five or six additional forests will be reviewed in 2005. Also in 2005, Sale Administrator certification exams, Sale Inspector certification exams, and Sale Administrator maintenance inspections will occur on several forests. The Regional Office staff director responsible for Timber Management has identified BMP implementation, particularly pertaining to SMZ protection, skid trails, and landings, as emphasis items for Sale Administrators during these reviews and inspections. Preliminary BMPEP monitoring results and associated corrective actions were presented at the Regional Forest Management Conference on April 28, 2004. |

| | |
|---|---|
| | b) BMP training will occur on each Forest by the end of 2006.<br><br>c) Monitoring targets for this activity were increased in 2004.<br><br>d) Forests continue to implement the RWQCB waivers and have been reminded of their requirements in a variety of formal and informal ways. |
| Priority | 1 |
| **T-2** | |
| Issue 2 | While implementation rates for skid trails (T02) from 1992 through 2002 were acceptable (84%), they declined from 86% to 81% between the 1992-1996 and 1997-2002 monitoring periods. Relatively few timber activities had elevated effects on water quality, but skid trails represented a substantial percentage of those sites. |
| Corrective Action | a) See T-1.<br><br>b) BMP implementation and effectiveness will be improved by emphasizing proper skid trail location and drainage and erosion control. Particular focus will be placed on the layout and administration phases of projects. |
| Status | See T-1. |
| Priority | 1 |
| **T-3** | |
| Issue 3 | Implementation and effectiveness rates of landing BMPs (T04) were not particularly problematic. In addition, relatively few timber activities had elevated effects on water quality. Nonetheless, landings represent a substantial percentage of those sites. |
| Corrective Action | a) See T-1.<br><br>b) To improve BMP implementation, forests will emphasize proper landing location, drainage (e.g., placement of waterbars), and stabilization, especially during layout and administration. Interdisciplinary teams (IDT) will be encouraged to consider using contract clauses that provide for special erosion control and prevention [C(T)6.602] near watercourses and on unstable terrains. IDTs will also be directed to exercise caution when reusing existing landings that may not have been optimally located, designed, or constructed. |
| Status | a) See T-1.<br><br>b) Monitoring targets for this activity will be increased in 2005. |
| Priority | 1 |
| | |

### 2.5.3. Engineering

In general, the performance of the engineering program from 1992 through 2002 was satisfactory. BMPs were implemented at 85% of monitored sites and were effective 89% of the time. Effects classified as elevated were relatively infrequent (46, <3% of sites), but occurred more often than in most other program areas. Road-related BMPs, especially road surface drainage and slope protection and stream crossings were the most problematic and accounted for most of these effects. Specific issues and corrective actions associated with engineering practices are described in Table 13.

**TABLE 13: Issues and Corrective Actions, Engineering**

| **E-1** | |
|---|---|
| Issue | Implementation and effectiveness rates of road surface drainage and slope protection BMPs (E08) were not particularly problematic. However, these activities represented a disproportionately large percentage of the sites with elevated effects on water quality. |
| Corrective Action | a) Watershed and roads analysis will continue to be used to identify opportunities to reduce the amount of inadequately maintained roads, where problems are more likely to occur.<br><br>b) The Regional Office will continue to emphasize road maintenance and as appropriate, decommissioning, by placing a high priority on these projects through the Ten Percent Roads and Trails (TRTR) and deferred maintenance funding processes. Forests will continue to focus attention and resources on these BMPs. Specifically, forests will continue internal pooling of engineering, fisheries, and watershed funding with external grants to implement road restoration projects (e.g., over the past several years, forests have used matching USFS funds to obtain several million dollars per year in road restoration grants from various outside sources).<br><br>c) Through technology transfer (e.g., USFS Water/Roads Interaction products), site visits, functional assistance trips, and program reviews, the Regional Office will continue to disseminate information and specific examples of good and poor road construction and maintenance practices to the forests.<br><br>d) These practices will be emphasized in BMP training.<br><br>e) More monitoring will be focused on this activity. |
| Status | a) Watershed and roads analysis continue to be implemented throughout the Region. All Forests have completed a forest-level roads analysis. Forests have conducted watershed analysis on 71 watersheds comprising 7.4 million acres in CA. Analyses for an additional 28 watersheds covering 3 million acres are planned or underway.<br><br>b) Project proposal requests for 2007 TRTR and deferred maintenance funding will be sent to the forests in 2005. These will continue to emphasize watershed improvement and correction of passage problems for aquatic organisms. Congressional earmarks were also used to address anadromous fish passage issues in FY 2003 and 2004. This focus will continue if these earmarks remain in 2005.<br><br>c) Informal Regional Office reviews and Functional Assistance Trips for road system |

| | |
|---|---|
| | operation and maintenance occurred on the Sequoia, Stanislaus, Eldorado, Plumas, Klamath, San Bernardino, and Mendocino national forests in FY 2004. Informal reviews will be conducted on at least five national forests in FY 2005 along with any Regional Office Directors' reviews that may be scheduled. As opportunities and issues arise, the Regional Office continues to disseminate information and specific examples of good and poor road construction and maintenance practices to the forests.<br><br>d) BMP training will occur on each Forest by the end of 2006.<br><br>e) Monitoring targets for this activity were increased in 2004. A combined hillslope/instream BMP validation study (see Section 3.2) that addresses this activity was initiated in 2004. |
| Priority | 1 |
| **E-2** | |
| Issue | Implementation and effectiveness rates for stream crossings (E09) were fairly high from 1992 through 2002 (85% and 88%, respectively). However, activities related to road crossings represented a disproportionately large percentage of the sites with elevated effects on water quality and many of these occurred during the most recent monitoring period (1997-2002). |
| Corrective Action | See E-1. |
| Status | See E-1. |
| Priority | 1 |
| **E-3** | |
| Issue | While implementation rates for water source development (E16) increased from 74% to 86% between the first and second monitoring periods, effectiveness rates remain low and declined between the first and second monitoring periods. Roads appear to be the cause of poor effectiveness in many cases. |
| Corrective Action | a) See E-1 (a) through (e). |
| Status | a) See E-1 (a) through (d).<br><br>b) Monitoring targets for this activity were increased in 2004. |
| Priority | 2 |
| **E-4** | |
| Issue | Implementation rates for in-channel construction (E13) were inadequate (71%). While these quantitative rates are based on a small sample size (n=24), the inherent risk associated with these activities warrants additional attention. |
| Corrective Action | a) See P-5. |

| | |
|---|---|
| | b) See E-1 items (c), (d), (e). |
| Status | a) See P-5.<br><br>b) See E-1 items (c), (d), (e). |
| Priority | 2 |
| **E-5** | |
| Issue | During the 1992-2002 monitoring period, implementation rates for snow removal (E17) were acceptable (86%). However, these rates declined substantially between the first and second monitoring periods (94% to 77%). |
| Corrective Action | a) Forests will review all existing snow removal contracts to ensure that applicable water quality requirements have been included. Contract modifications will be made as necessary. Water quality provisions will be emphasized to contractors through formal and informal correspondence. Contracting Officers will be reminded that all new contracts must contain needed water quality provisions.<br><br>b) More monitoring will be focused on this activity. |
| Status | a) Forests will review snow removal contracts in 2005 and make any required changes in 2006. Water quality provisions pertaining to snow removal will be emphasized to contractors prior to winter of 2004-2005.<br><br>b) Monitoring targets for this activity were increased in 2004. |
| Priority | 2 |
| **E-6** | |
| Issue | Implementation of BMPs for restoration of borrow pits and quarries (E19) needs improvement. |
| Corrective Action | These practices will be emphasized during engineering and mining program reviews and in BMP training. In particular, the need to develop and implement restoration plans will be stressed. |
| Status | BMP training will occur on each Forest by the end of 2006. |
| Priority | 2 |
| | |

### 2.5.4. Recreation

Overall, BMP implementation rates for recreation were fairly low (68%) during the composite monitoring period. However, it is not clear whether these results are representative of the program. Many evaluations were excluded from this report due to the issues described in Tables A-1 and 3. The low rates for recreation practices as a whole were driven by poor implementation of dispersed recreation BMPs. Results also show that these BMPs were generally effective when they were implemented. Effects were classified as elevated at four (2%) recreation sites, which were caused by roads at all but one site. It is suspected that many of the problems associated with these sites were due to the fact that they were developed prior to today's standards (e.g., buffer widths). Specific issues and actions needed to improve execution of the water quality components of recreation activities are provided in Table 14.

**TABLE 14: Issues and Corrective Actions, Recreation**

| **R-1** | |
|---|---|
| Issue | See E-1. |
| Corrective Action | See E-1. |
| Status | See E-1. |
| Priority | 1 |
| **R-2** | |
| Issue | a) At developed recreation sites, major departures from requirements to exclude substances that could affect water quality from within 100 feet of watercourses were found 20% of the time. Minor departures occurred at 69% of sites. Washing of food and animals wastes at hydrants and faucets was found at 18% of sites and sediment delivery to stream channels occurred 21% of the time. |
| Corrective Action | a) Concessionaires will be formally informed of requirements to exclude possible contaminants from with 100 feet of water and to avoid washing of food and animal wastes near hydrants and faucets. Concessionaires will be encouraged to notify the public, through a variety of means (e.g., signage), to adhere to these requirements. Developed sites will be assessed for possible sediment sources and site-specific remedies during reauthorization of special use permits. The Capital Improvement Program (CIP) or other means will be used to address sites where major investments are necessary to meet all BMP requirements.<br><br>b) Forests will emphasize these BMPs during their training sessions. |
| Status | a) Concessionaires will be notified via letter in 2005. Developed sites will be assessed for possible sediment sources and site-specific remedies during reauthorization of special use permits, which varies by site. CIP project proposals will be submitted as needed. |

| | |
|---|---|
| | b) BMP training will occur on each Forest by the end of 2006. |
| Priority | 2 |
| **R-3** | |
| Issue | Implementation rates for dispersed recreation BMPs (R30) were low (50%). The sample size for this activity is small because the protocol was just recently developed and implemented. It is therefore unclear whether these results represent isolated cases or if implementation problems are more extensive. |
| Corrective Action | a) Forests will emphasize these BMPs in their training sessions.<br>b) More monitoring will be focused on this activity so that additional data are available to determine if BMP implementation problems for this activity are widespread. |
| Status | a) BMP training will occur on each Forest by the end of 2006.<br>b) Monitoring targets for this activity will be increased in 2005. |
| Priority | 2 |
| | |

### 2.5.5. Grazing

As previously described, quantitative analysis of grazing BMPs was not possible. However, based on a qualitative analysis, there appear to be modest problems associated with implementation of these BMPs. Attaining some of the effectiveness criteria, including streambank disturbance and riparian ground cover, may also be problematic. However, as described elsewhere (Table A-1), streambank disturbance and riparian cover data should be viewed with caution because the methods used have been determined to provide inconsistent results. Few (5, <4%) sites had potentially significant water quality effects. More specifics regarding these issues are described in Table 15.

**TABLE 15: Issues and Corrective Actions, Grazing**

| G-1 | |
|---|---|
| Issue | a) See P-7.<br><br>b) Previous standards and guides (S&G's) used to monitor grazing utilization in riparian areas were inconsistent from Forest to Forest and were not found to provide reliable results in terms of rangeland health.<br><br>c) Many Rangeland Environmental Analyses and Allotment Management Plans (AMPs) are out of date and/or insufficient. |
| Corrective Action | a) See P-7.<br><br>b) Forest Plans in the Sierra Nevada were modified by the new Standards & Guidelines (S&G's) from the Sierra Nevada Forest Plan Amendment. The new S&G's will provide better consistency for monitoring and protecting riparian areas across the Sierra Nevada.<br><br>c) There has been a change in Regional and National priorities to increase the emphasis on completing Rangeland Environmental Analyses and AMPs. New direction is being adopted Regionally and Nationally. This review process will include water quality specialists and is expected to maintain conditions where they are good and improve conditions where they are not.<br><br>d) Since 1999, the Region has been implementing a Range Monitoring Program to assess long-term rangeland condition and trends. The program will also provide ecological classifications and quantitative condition scorecards for meadows, which will provide a basis for range conservationists, wildlife biologists, hydrologists, soil scientists, and fisheries biologists to assess meadow conditions and evaluate whether management changes are necessary. |
| Status | a) See P-7.<br><br>b) Implementation of new grazing standards in the Sierra Nevada is ongoing.<br><br>c) Implementation of new direction emphasizing Rangeland Environmental Analyses and AMPs will begin in 2005. As a result, a marked increase in the number of completed Rangeland Environmental Analyses and updated AMPs is expected over the next 5 years.<br><br>d) The Region continues to implement its Range Monitoring Program. Preliminary ecological classifications have been developed based on results from 785 permanent plots. Scorecards to rate ecological condition for the sampled meadows are expected in 2005. Subsequently, these results will be used to inform management decisions regarding grazing in different meadows (see Section 3.9). |
| Priority | 1 |

### 2.5.6. Prescribed Fire

Prescribed fire BMPs were highly effective (98%) when they were implemented. However, implementation rates were not particularly high during the 1992-2002 monitoring period (77%) and declined between the first and second monitoring periods (79% and 74%, respectively). While elevated effects on water quality were extremely rare (1, <1%), additional focus on implementation of these BMPs is necessary because this activity is being conducted more often than in the past. Additional details are provided in Table 16.

**TABLE 16: Issues and Corrective Actions, Prescribed Fire**

| **F-1** | |
|---|---|
| Issue | BMP implementation rates for prescribed fire declined between the first and second monitoring periods, from 79% to 74%. With additional use of this tool, implementation of these BMPs is becoming increasingly important. |
| Corrective Action | a) Through a variety of means (e.g., formal direction, program reviews, site visits), the Regional Office will direct forests to place additional emphasis on these BMPs, both in project planning and implementation. Forest Earth Scientists will increase participation in the planning of prescribed fire projects.<br>b) These practices will be emphasized during BMP training sessions.<br>c) Additional monitoring will be focused on this activity.<br>d) Continued implementation of the recently adopted RWQCB timber harvest waivers is expected to improve BMP implementation for this activity, since it requires interdisciplinary review of projects. |
| Status | a) Fuels program reviews are scheduled to occur on the Los Padres and Tahoe national forests in 2005.<br>b) BMP training will occur on each Forest by the end of 2006.<br>c) Monitoring targets for this activity were increased in 2004.<br>d) Fuels projects are continuing to be implemented under the new timber waiver. |
| Priority | 1 |
| | |

### 2.5.7. Mining

As described previously, results associated with much of the mining data are not yet available. Only qualitative results were available for mining operations associated with locatable minerals (M26). Based on these results, there appear to be no significant problems associated with implementation of these BMPs. Only one site (1%) had water quality effects ranked as elevated. Nonetheless, the effectiveness of these BMPs requires some improvement. Specific issues are described in Table 17.

**TABLE 17: Issues and Corrective Actions, Mining**

| **M-1** | |
|---|---|
| Issue | Approximately 15%-19% of mining sites associated with locatable minerals have evidence of erosion or sediment delivery from dumps, excavations, and fillslopes. |
| Corrective Action | a) The Regional Office will emphasize these BMPs during reviews of the mining program.<br><br>b) The Regional Office and forests will prioritize legacy sites for restoration according to their risks and opportunities available to address them. Forests will pursue external funding to supplement appropriated funds.<br><br>c) Effective July 23, 2004, the Regional Office requires permit administrators to be certified or to operate under someone that is certified. This is expected to prevent the recurrence of legacy problems by improving the quality of permit administration for locatable minerals.<br><br>d) Forests will visit each mining operation at least once per year and identify, track, and resolve potential water quality issues at those sites. |
| Status | a) The Regional Office will conduct reviews of mining operations on at least three national forests in 2005.<br><br>b) The 2005 budget advice from the Regional Office will direct forests to prioritize mining sites for restoration and pursue external funding opportunities to supplement appropriated funds.<br><br>c) Effective July 23, 2004, the Regional Office requires permit administrators to be certified or operate under someone that is certified.<br><br>d) The FY 2005 budget advice will also direct forests to visit all mining operations at least once per year. The highest priority (top one-third) sites will be visited with mining permittees. All needed corrective actions at each site will be documented and tracked to completion by the forests. |
| Priority | 2 |

| M-2 | |
|---|---|
| Issue | See E-6. |
| Corrective Action | See E-6. |
| Status | See E-6. |
| Priority | 2 |
| | |

### 2.5.8. Vegetation Management

The vegetation management program performed very well from 1992 to 2002. Implementation rates were high from 1992 through 2002 (87%) and improved between the first and second monitoring periods. Effectiveness rates were also high (89%) and remained so throughout the composite monitoring period. Only one (<1%) vegetation management site had effects on water quality that were classified as elevated. No issues or corrective actions were identified for this program.

## 3. RELATED MONITORING PROGRAMS

Besides the BMPEP Onsite Evaluations described in Section 2, the USFS has implemented several complimentary monitoring programs, many of which include an instream monitoring component. These programs, described below, use a variety of approaches to address different water quality and aquatic ecosystem monitoring questions at different spatial and temporal scales. Issues addressed by these programs include validation of BMP effectiveness, evaluation of compliance with regulatory standards, assessment of conditions and trends in water quality and aquatic resources, and development and validation of models for assessing cumulative watershed effects (CWE).

### *3.1. Regional Bioassessment Program*

The USFS has developed one of five scientifically valid bioassessment programs in the State (SWRCB 2002). This program is intended to: 1) biologically classify streams in the Region according to macroinvertebrate communities; and 2) assess water quality conditions and trends in these ecosystems. Two separate, complimentary approaches have been pursued to achieve these objectives. The first is development and application of a Regional multivariate bioassessment model based on the River Invertebrate Prediction and Classification System (RIVPACS) approach. The second is development and application of sub-Regional Benthic Indices of Biotic Integrity (B-IBI), which use multi-metric methods.

### 3.1.1. Multivariate Methods

Through a partnership with Utah State University, the USFS developed a RIVPACS model that is applicable on national forests and surrounding lands throughout California. RIVPACS is a standard method of bioassessment in Great Britain and Australia and is increasingly being used by Federal and State agencies in the western United States (Hawkins 2003a and 2003b).

RIVPACS-type water quality assessments are conducted by comparing taxa expected to occur at a site under relatively undisturbed conditions (E) to those that are actually observed at the site (O). These models have been demonstrated to detect biological impairment from land use activities in watersheds up to approximately 10,000 acres in size. Expected taxa are predicted by multivariate statistical models based on invertebrate data and other physical and chemical parameters collected from high quality "reference" streams. The O/E ratio is the proportion of taxa measured at a site to those that should occur in the absence of significant anthropogenic disturbance. Consequently, O/E ratios near a theoretical mean of 1.0 represent high biological integrity and values significantly less than 1.0 indicate possible impairment (Hawkins 2003a and 2003b).

A complete RIVPACS model was developed in 2004 based on samples from 176 reference sites on national forests and national parks in California (Figure 23). The following site variables were found to be strongly correlated with the observed biological communities and are consequently used as predictor variables in the model: elevation, average number of wet days per year, latitude, sampling date, watershed area, average annual precipitation, longitude, and alkalinity. Based on these predictor variables and macroinvertebrate data, O/E scores were calculated for reference sites (Figures 24). The model was found to be accurate (i.e., mean of 1.01 compared to a theoretical mean of 1.0) and precise (standard deviation = 0.14) compared to RIVPACS-type models developed for other areas (Hawkins 2003a and 2003b).

The model was then tested against 52 test (i.e., potentially impaired) sites and was shown to discriminate between reference and test sites (Figures 25 and 26). Beyond this development and testing, the model has been applied as part of the monitoring component of the Heavenly Valley TMDL Implementation Plan (Section 3.9). It is also being applied, along with the B-IBI described in Section 3.1.2, as part of a University of California, Santa Barbara monitoring project on the Los Padres National Forest.

**Figure 23. Distribution of 176 reference sites on national forests and national parks in CA.**

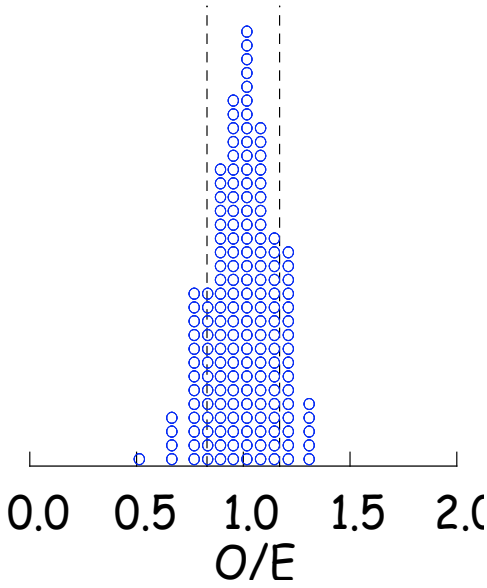


**Figure 24. Frequency Distribution of Reference Site O/E values (from Hawkins 2003b)**

Mean = 1.01, Standard Deviation = 0.14

10th and 90th percentiles (dashed lines) are often used as thresholds to infer impairment.

10th percentile = 0.83, 90th percentile = 1.17

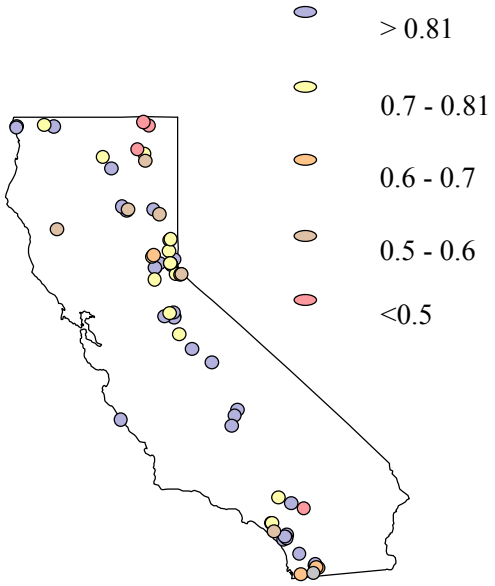


**Figure 25. O/E Values for Test Sites (from Hawkins 2003b)**

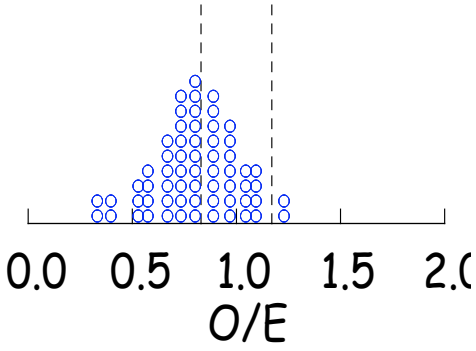


**Figure 26. Frequency Distribution of Test Site O/E Values (from Hawkins 2003b)**

Mean = 0.81, Range = 0.33 – 1.25.

60% of test sites were not reference quality based on 10th and 90th percentile thresholds.

### 3.1.2. Multimetric Methods

To compliment this multivariate approach to bioassessment, the USFS collaborated with the California Department of Fish and Game (CDFG), the San Diego Regional Water Quality Control Board, and the U.S. Environmental Protection Agency to enhance an existing preliminary Benthic Index of Biotic Integrity (B-IBI) for the southern California coastal region (Ode et al. 2004). While different field protocols were used to collect samples, results obtained from sites at which both protocols were used were found to be strongly and consistently correlated. Consequently, data from 56 sites on national forests were combined with data from 220 other sites in Southern California to produce a final B-IBI (Figure 27). The distribution of B-IBI scores from the sites used to develop the model is shown in Figure 28a. Once the model was developed, it was validated against an independent dataset of reference and test sites. As shown in Figure 28b, this validation effort demonstrated the model's ability to discriminate between populations of reference and test watersheds.

Besides producing an analytical tool that compliments the Regional RIVPACS model, this study demonstrated that there is promise for a more unified statewide bioassessment program in California. Specifically, the results suggest that integration of disparate datasets may be possible. This would overcome what the SWRCB (2002) considers to be the single largest barrier to an integrated program.

In the future, the USFS plans to pursue additional opportunities for data integration and refinement and development and application of B-IBI throughout its lands in California.

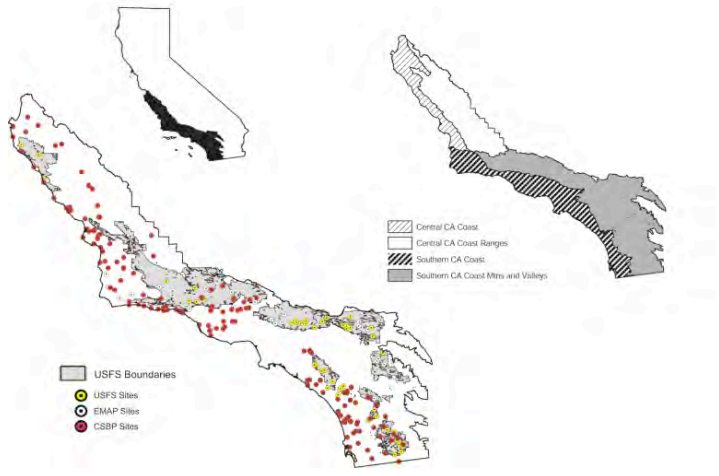


Figure 27. Distribution of sites used to produce a B-IBI for Southern Coastal CA (from Ode et al. 2004)

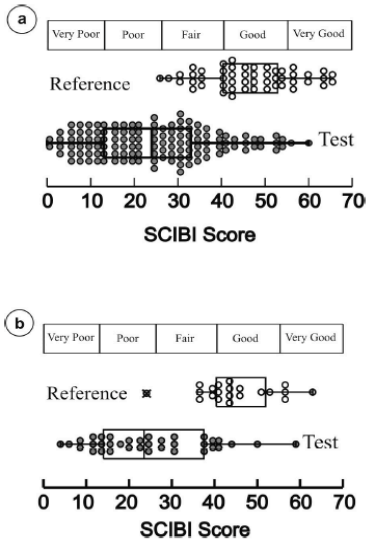


Figure 28. Distribution of B-IBI scores for the datasets used to (a) develop and (b) validate the model (from Ode et al. 2004)

## *3.2. Northern Province Administrative Study*

The USFS Pacific Southwest Regional Office and the University of California, Berkeley signed an agreement in 2003 for the first of a planned five-year study to evaluate cumulative watershed effects (CWE) and BMP effectiveness on the Klamath National Forest (KNF). Scientists from USFS Pacific Southwest Research Station (PSW) are also participating in this investigation.

The objectives of the study are to:

- Evaluate whether existing KNF erosion models can be used to explore the influence of sediment supply on stream channel conditions.
- Assess whether empirical relationships and digital elevation models can successfully delineate the spatial extent of channel types and median grain sizes throughout the study watersheds.
- Determine how biologically significant properties of different types of channels respond to changes in coarse and fine sediment supply.
- Verify whether biomonitoring with macroinvertebrates is an effective tool for detecting altered channel conditions resulting from changes in sediment supply.
- Validate the degree to which road management BMPs are effective in protecting beneficial uses of water.

In the CWE portion of this study, habitat conditions and macroinvertebrates are being sampled in 20 or more reaches located in KNF watersheds with significantly different rates of current and past anthropogenic alterations of natural sediment supply regimes. Assessments of condition will be made by comparing stream channel attributes observed in the field to those predicted using an analytical reference condition model (Power et al. 1998). This model, which predicts channel attributes using well-established physical principles and theoretically and empirically based knowledge of watershed and stream channel processes, is expected to control for some of the significant variability that naturally occurs between different streams. This portion of the study will also further evaluate the existing USFS RIVPACS model (Section 3.1). Specifically, this study will assess whether it can be used to detect the biological effects of increased sediment supplies to streams. In addition, two new multivariate models will be developed specifically for the Klamath region. The first new model will use physical habitat estimates from the analytical reference condition model and other field data to predict macroinvertebrate community composition at future test sites. The second model will predict macroinvertebrate communities based on predominant species traits (e.g., body size, presence of protective cases) observed in channels of varying habitat quality.

The BMP effectiveness component of this study is using measurements of sediment delivery, channel morphology, and macroinvertebrates in a before-after control-impact (BACI) study design to evaluate the degree to which USFS road management BMPs protect beneficial uses of water. The study is focused on road decommissioning and storm-proofing projects on KNF.

More details regarding this study can be found in May et al. (2004). Since the study was initiated in the summer of 2004, results are not yet available.

## *3.3. Northwest Forest Plan Aquatic Riparian Effectiveness Monitoring*

The USFS and the Bureau of Land Management are jointly implementing the Northwest Forest Plan Aquatic and Riparian Effectiveness Monitoring Plan (AREMP). It is intended to characterize the ecological condition of watersheds, streams, and riparian areas on federal lands covered under the Northwest Forest Plan (NWFP). This includes the Mendocino, Shasta-Trinity, Six Rivers, Modoc, and Klamath national forests in California. AREMP will assess present watershed conditions, track trends in watershed condition over time, and report on the NWFP's effectiveness across the region. Although its focus is on characterizing ecosystem status and trend, AREMP will also supply information useful in determining causal relationships (Reeves et al. 2001).

Key questions to be addressed by AREMP include (Reeves et al. 2001):

1. Are the key processes that create and maintain habitat conditions in aquatic and riparian systems intact?
    - What is the status of upslope processes as indicated by vegetation, roads and stream crossings, and landslides in the watershed?
    - What is the status of riparian processes as indicated by vegetation composition, structure and diversity, roads and stream crossings, and floodplain connectivity?
    - What is the status of in-channel processes as indicated by pools, sediment flux, substrate, water temperatures, large structure in the channel, and rates of channel movement?
    - What is the status of the fauna as indicated by fish, amphibians, and macroinvertebrates?

2. Has the distribution of these and other key indicators shifted in a direction indicating improved or degraded habitat and biotic condition?
    - How does the aggregate quality of the key indicators used to evaluate watershed condition change through time under the Northwest Forest Plan?
    - Are current management practices at the site and watershed scales attaining the Aquatic Conservation Strategy objectives?

Over a five-year period, a total of 250 watersheds will be sampled in Washington, Oregon and northern California within the NWFP area. Watershed conditions are being assessed by analyzing indicator values using a decision support model that incorporates physical, chemical, and biotic relationships developed by provincial and regional experts. Figure 29 shows the sites in California that have been or will be sampled as part of AREMP. Additional details, including a 2002 Annual Report can be found at: http://www.reo.gov/monitoring/watershed/index.htm.

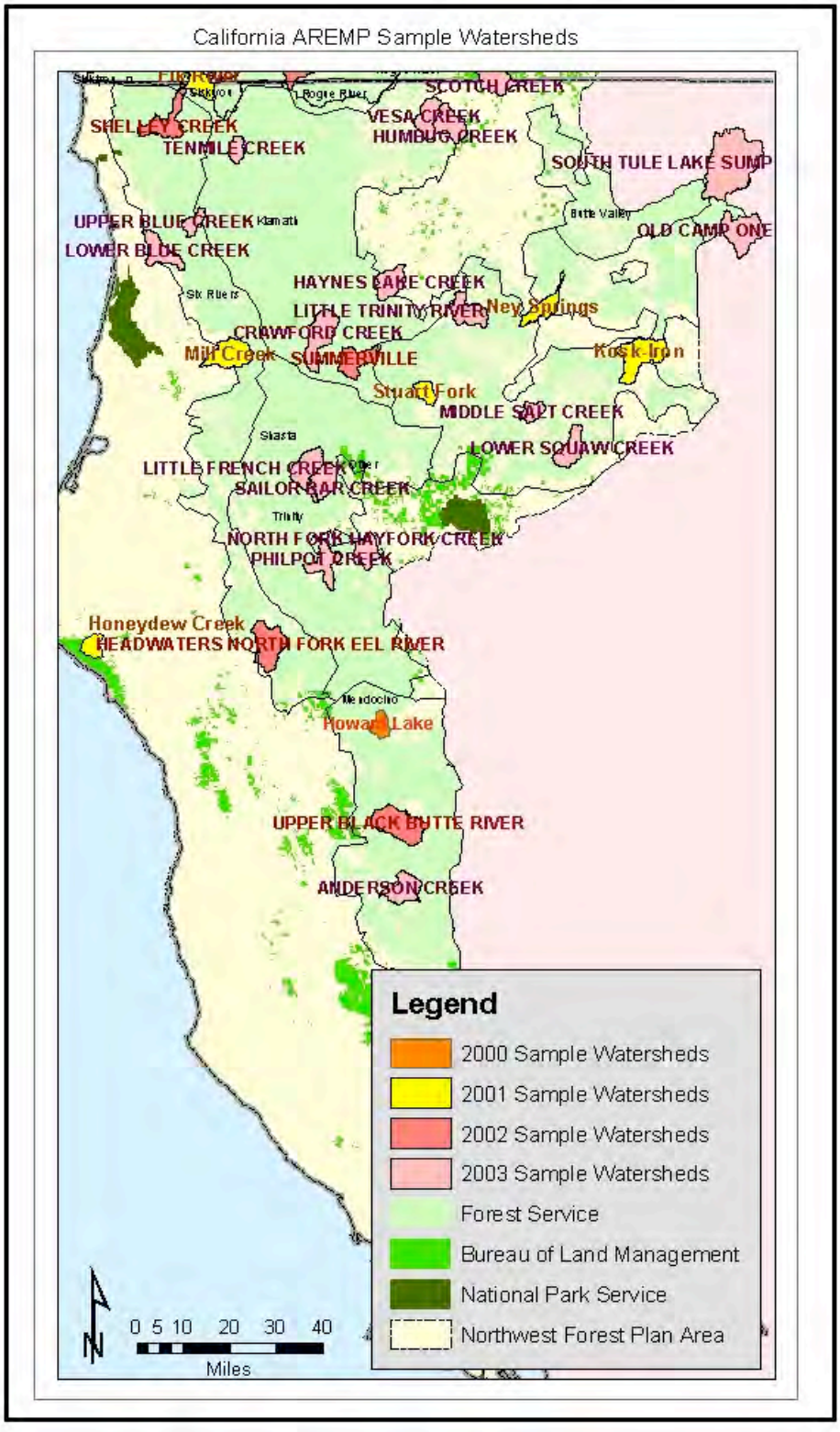


**Figure 29. AREMP Sample Watersheds in California.**

## *3.4. Cumulative Watershed Effects in the Central Sierra Nevada*[10]

Since 1999, the USFS and the California Department of Forestry and Fire Protection have funded Colorado State University (CSU) to investigate cumulative watershed effects (CWEs) in the Central Sierra Nevada. The USFS objectives are to develop flexible, user-friendly, GIS-based models to predict changes in flow, sediment production, and ultimately, sediment delivery for watersheds ranging from approximately ten to several hundred square kilometers.

### 3.4.1. Field Investigations

Field investigations in support this effort have focused on (1) quantifying sediment production and sediment delivery from timber harvest, roads, wild and prescribed fires, off-road vehicles, and undisturbed areas; (2) quantifying the year-to-year variability in sediment production; and (3) determining the effect of key site variables such as elevation, slope, percent cover, soil type, and contributing area on sediment production rates.

Sediment production rates are being measured with sediment fences. Ninety-one fences were constructed in the 1999. Since the working hypothesis was that roads and severely burned areas would generate more sediment than other sources, CSU installed 27 sediment fences at the outlets of road drainage structures (e.g., waterbars, rolling dips, and cross-relief culverts), 36 sediment fences at the outlets of waterbars on skid trails, 7 sediment fences on rills and gullies draining off-highway vehicle (OHV) trails, 15 sediment fences on hillslopes burned by prescribed fires, 3 fences on hillslopes burned by a high-severity wildfire, and 3 fences on minimally-disturbed hillslopes (Table 18).

There was considerable variability in sediment production rates between the different land uses within the first wet season. The median sediment production rate from roads was 0.2 kg $m^{-2}$, or nearly an order of magnitude higher than any of the other sources (Figure 30). The sediment production rates within a given land use generally were highly skewed, with a few sites producing the majority of the sediment from that land use. Hence the mean sediment production rate from roads was 0.9 kg $m^{-2}$, or nearly five times the median value. In comparison, the mean sediment production rate was 0.1 kg $m^{-2}$ from skid trails, 0.4 kg $m^{-2}$ from ORV trails, and just 0.001 kg $m^{-2}$ from minimally disturbed sites. When the burned sites were separated by burn severity, the sites burned at high severity had a mean sediment production rate of 1.1 kg $m^{-2}$ (n=3), or approximately 1,000 times greater than the mean value of 0.001 kg $m^{-2}$ from sites burned by prescribed fire (n=15).

Native surface roads produced 10-50 times more sediment than rocked roads. Skid trails on Holland soils produced an average of 0.9 kg $m^{-2}$ (n=2) of sediment, and this was significantly more than the mean value of 0.04 kg $m^{-2}$ for the skid trails on all other soil types (n=34).

[10] This section is a slightly edited version of MacDonald et al. (2004).

| Table 18. Number of sediment fences by land-use type for each of three wet seasons. | | | |
|---|---|---|---|
| | Wet season | | |
| **Land-use type** | **1999-2000** | **2000-2001** | **2001-2002** |
| Roads | 27 | 47 | 66 |
| Skid trails | 36 | 48 | 10 |
| OHV | 7 | 7 | 7 |
| Fire | 18 | 18 | 3 |
| Undisturbed | 3 | 3 | 0 |
| Total: | 91 | 123 | 86 |

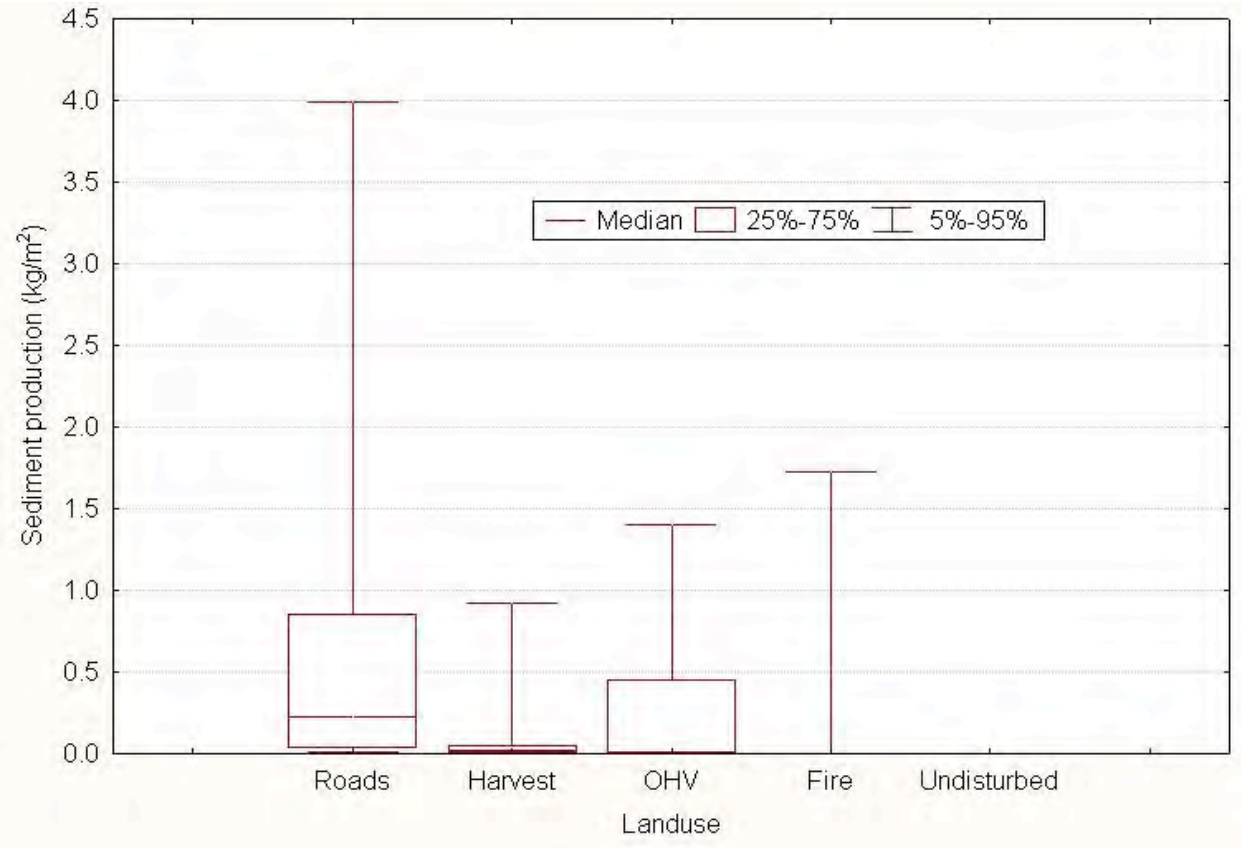


Figure 30. Sediment production by dominant land use for the 1999-2000 wet season.

Results from the first wet season supported the initial hypothesis and, consequently, efforts in the second and third years focused on sediment production from unpaved roads. Although it was not possible to add additional sediment fences on areas burned at high severity, the number of fences on roads increased from 27 in the first year to 47 in the second year and 66 in the third year (Table 18). Since some of the lower-producing sites were not monitored in all three years, a total of 300 fence-years of data have been collected.

Sediment production rates from roads in the second and third wet seasons were only 10-30% of the values measured in the first wet season (Figure 31). The sediment production rates for skid trails, OHV trails, burned sites, and undisturbed areas showed a similar decrease. The largest decline was for the three sites burned at high severity, where the second year sediment production rates were an order of magnitude lower than in the first year, and the third year rates were another 70% lower than the second year rates. This decrease is attributed primarily to the increase in vegetative cover, as this has been shown to be the largest control on post-fire sediment production rates in other areas.

The decline in sediment production rates in the second and third seasons for the other land uses generally can be attributed to differences in the magnitude and type of precipitation. Total precipitation in the first wet season was 45% higher than the second wet season and 22% higher than in the third wet season. Perhaps more importantly, storms in the second and third wet seasons generally were colder than in the first wet season, so the rainfall erosivity was approximately 90% higher in the first wet season than in the second and third wet seasons. The larger and more persistent snowpack at most of our sites apparently protected the surface from rainsplash erosion and may also have slowed any overland flow.

Taken together, the three years of data confirm that roads, high-severity wildfires, OHV trails, and certain skid trails were the dominant sediment sources at the hillslope scale. Sediment production rates were highly variable between sites within a year as well as between years. Multivariate analyses indicate that the dominant controls on road sediment production include road contributing area (A), road gradient (S), annual erosivity ($E_A$), and road surfacing (rock vs. native surface; T). An empirical model containing these variables explained 54% of the variability in annual road sediment production. It was also found that road segments receiving runoff from adjacent rock outcrops produced four times more sediment than comparable segments unaffected by rock outcrops. The observed variations in sediment production rates between sites and between years show the difficulty of developing accurate predictive models for CWEs.

In 2003 and 2004, the USFS funded CSU to expand this fieldwork to other parts of the Sierra Nevada. Specifically, these methods will be used as part of a study to evaluate the effects of fire and fuels treatments on hillslope erosion rates, water quality, and aquatic and riparian ecosystems in the Kings River watershed (Section 3.4). These methods are also being employed to quantify road erosion rates on the Lassen National Forest.

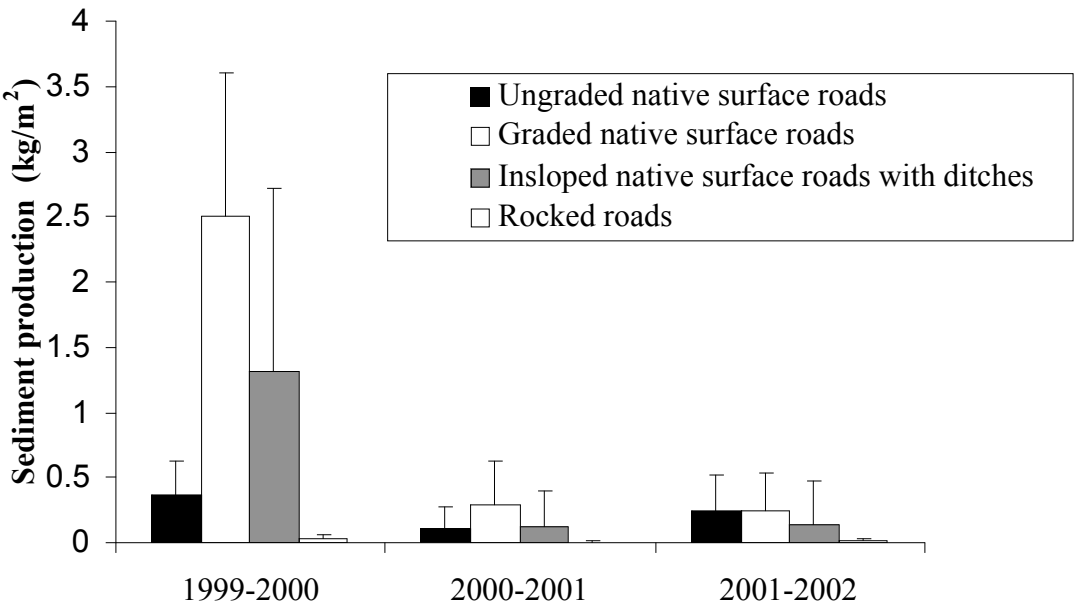


Figure 31. Magnitude and inter-annual variability in sediment production rates for various road drainage types and surfaces. Bars represent one standard deviation.

### 3.4.2. CWE Model Development

The goal of the modeling component of this study is to develop flexible, user-friendly, GIS-based models to assess CWE that better represent environmental processes and are validated to a greater degree than some commonly used tools, yet are simpler and less data intensive than complex physically-based models.

The first objective is to explicitly separate the procedures used to assess changes in flow from changes in sediment production. A second goal is to utilize the capability and greater sensitivity of spatially-explicit models, while still recognizing basic data limitations and the desire for models that can be easily applied by a range of users. The final objective is to provide users with the flexibility to change values and recovery rates to better represent their local conditions. A modular approach is being employed, so that new procedures can be added as these are developed or different issues arise.

A flow model, DELTA-Q version 1.0, was completed in June 2003. This model calculates changes in runoff based on activities such as forest harvest and fires (http://www.cnr.colostate.edu/frws/people/faculty/macdonald/macdonald.html). It estimates catchment-scale changes in high, median, and low flows resulting from changes in forest cover due to timber harvest or fires. Changes can be calculated in absolute terms or as a percentage. The input data are GIS layers representing the extent, type, and years of the different activities. Users determine the flows of interest and select values for the change in flow for each activity type and the time to hydrologic recovery. Help files provide data from an analysis of changes in flow from 26 paired-watershed studies (Austin 1999). Each model run calculates the change in flow over the chosen time period for one activity layer. The model sums the changes in flow from multiple runs using different activity layers to obtain a total change in flow for the area of interest. Tables of the individual and total changes in flow over

time can be exported as text files for plotting, report preparation, or other analyses.

The second model is the FORest Erosion Simulation Tool (FOREST), and in its first iteration this is designed to calculate changes in surface erosion resulting from forest harvest, unpaved roads, and fires. The explicit separation of changes in flow and surface erosion will help users to recognize the different magnitudes of change and different recovery periods for these two different types of CWE. Once FOREST is released, work will begin on a third model to route the sediment produced on hillslopes into and through stream networks.

As in the case of DELTA-Q, the input data for FOREST are one or more GIS coverages with the activities of interest. There are separate procedures for calculating sediment production from linear features (e.g., roads) and from polygons. The modular structure means that FOREST provides the user with several options for calculating sediment production rates, depending on data availability and the desired level of complexity.

For roads and other linear features, the options within FOREST include fixed sediment production rates per unit road length for each road type and empirical models (e.g., Luce and Black, 1999). Alternatively, users can run a set of simulations outside of FOREST using models such as the Water Erosion Prediction Project (WEPP, http://forest.moscowfsl.wsu.edu/fswepp/). Depending on the data available and the desired level of complexity, users can stratify their roads layer and then use FOREST to assign spatially-explicit values to the different road segments.

The polygon module is used to calculate sediment production rates from activities such as forest harvest or fires. The required input is one or more polygon coverages that include the type(s) of disturbance and year of each activity. Users assign first-year sediment production rates to each activity and a time period for erosion rates to return to background levels. At this stage, a linear recovery is assumed, although users can also specify no recovery, as might be the case for unpaved roads with continuing usage. An additional polygon coverage can be used to adjust sediment production rates for factors such as fire severity, soil type, or elevation.

To help users, FOREST provides a lookup table of published post-fire erosion rates. Alternatively, the user can use programs such Disturbed WEPP to calculate sediment production rates and bring these in to FOREST. In contrast to DELTA-Q, FOREST converts vector data to raster data in order to perform raster-based calculations. Model outputs include sediment production grids for each year as well as a summary table of sediment production rates over time for the areas of interest. When FOREST is run on multiple layers of overlapping activities, the results can be combined into a grid to show maximum sediment production rates for the time period of interest.

The raster-based approach of FOREST will facilitate the development of proposed modules to deliver the sediment into and through the stream network. Given the data limitations and uncertainties in predicting sediment transport, we expect that the sediment delivery models modules will use a combination of empirical data and relatively simple algorithms based on key variables such as slope and drainage area. The final step will be to test the validity of these CWE models against data from a range of managed and relatively unmanaged watersheds.

## *3.5. Kings River Experimental Watershed Project*

The USFS Pacific Southwest Regional Office and USFS Pacific Southwest Research Station (PSW) are implementing the Kings River Experimental Watershed (KREW) Project, an adaptive management project on the Sierra National Forest (http://www.fs.fed.us/psw/programs/snrc). Key cooperators include the University of California (Santa Barbara), the University of Nevada, Colorado State University, and California State University (Fresno). The objectives of the project are to evaluate the effects of mechanical thinning and prescribed fire on key ecosystems processes and conditions, including those associated with aquatic environment.

Key aquatic resource questions being addressed are:

- What is the variability in the physical, chemical, and biological characteristics of headwater stream ecosystems and their associated watersheds, with and without vegetative treatments (e.g., thinning, prescribed fire)?
- What width and range of treatments for riparian buffers are most effective in maintaining and restoring aquatic, riparian, and meadow physical, chemical, and biological conditions?
- Over short and long time scales, how do fuels treatments affect erosion rates and soil health and productivity?

The study is being conducted in eight 50-100 hectare watersheds (Figure 32). Two of these watersheds will be thinned, two will be burned, two will be thinned and burned, and two will serve as controls (no treatments). Since this study is intended to represent the effects of typical fuels reduction projects conducted in the southern Sierra, they will be conducted according all management direction applicable to the Forest (e.g., standards and guidelines, BMPs). Consequently, the study will validate the degree to which USFS BMPs are effective in protecting water quality and aquatic ecosystems.

KREW is conducting a wide array of measurements that will provide a basis for observing and modeling the effects of fuels treatments. They will characterize meteorology, vegetation, fuel loading, soil characteristics, hillslope sediment production and delivery from different land types and disturbances, stream flow and sediment yield, stream channel morphology, macroinvertebrates, food webs, stream channel microclimate, streamflow, shallow soil, and precipitation chemistry.

A draft study plan is expected in 2005 and will be made available to interested parties for review. Baseline data analysis will also begin in 2005.

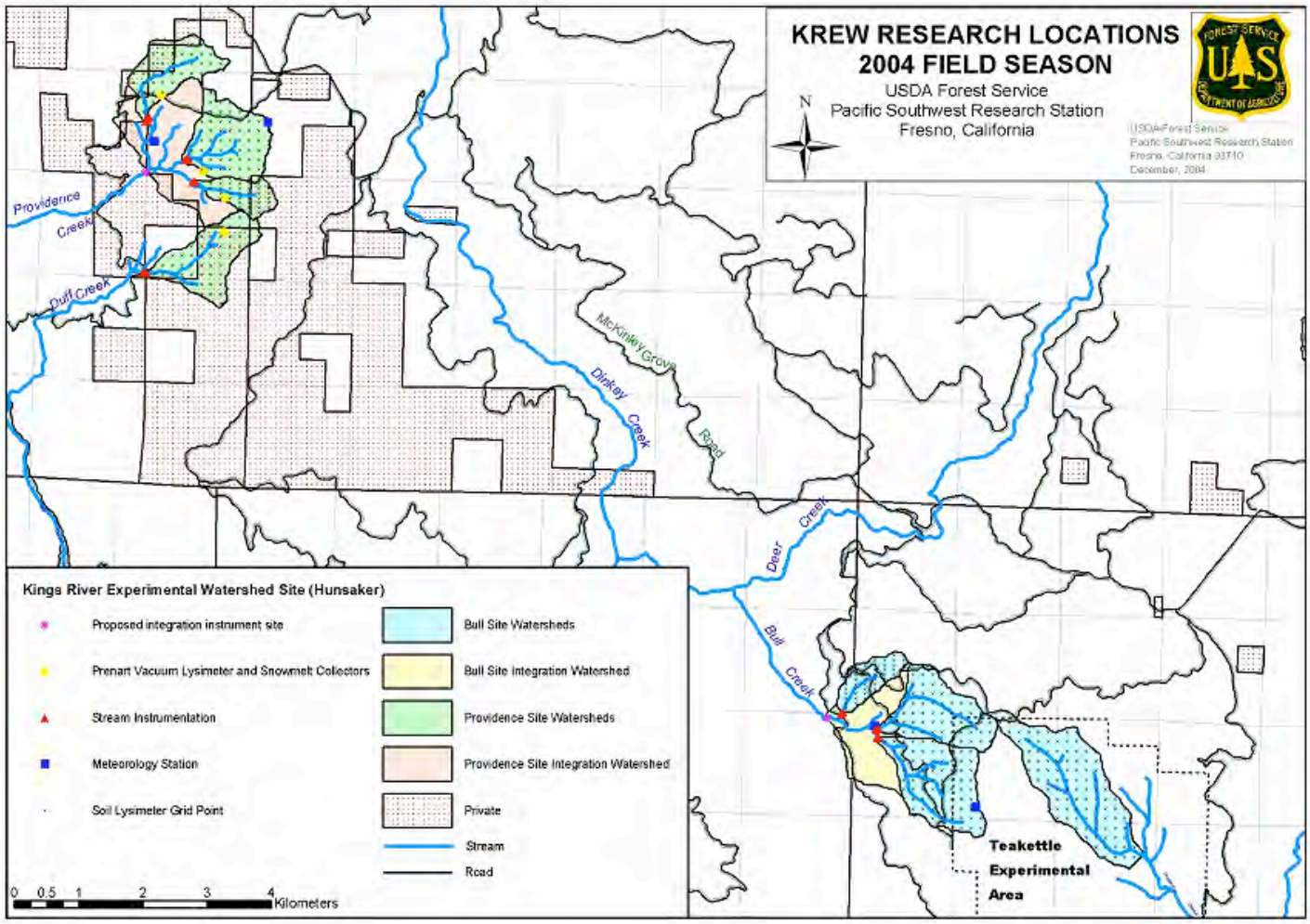


Figure 32. KREW Study Watersheds on Sierra National Forest

## *3.6.Herger-Feinstein Quincy Library Group Forest Recovery Act Monitoring*

The Herger-Feinstein Quincy Library Group Forest Recovery Act (HFQLG) is being implemented on the Lassen, Plumas, and Tahoe national forests. HFQLG projects are intended to reduce fire hazards, improve forest heath, and provide economic stability. A comprehensive monitoring program has been developed to: 1) provide information useful to mangers applying the principles of adaptive management; 2) assist the public in gauging the success of resource management activities; and 3) assess the effectiveness of the resource management activities in achieving resource objectives (USFS 2002).

This program includes stream monitoring to determine how stream channel and riparian attributes in the HFQLG project areas change over time. This includes those with areas with the

highest intensity of activities. The approach is to track changes in stream attributes, as measured by Regional Stream Condition Inventory (SCI) protocols (USFS 2004) in randomly selected "treated" sub-watersheds relative to changes in randomly selected "reference" watersheds. Measured attributes include macroinvertebrates, large woody debris, stream temperature, bankfull width and depth, substrate composition, channel cross sections, gradient, entrenchment ratio, habitat type, pool tail fines, number of pools, pool depths, streambank stability, stream shading, stream shore water depth, and streambank angle (USFS 2004).

A total of 14 sample reaches per year are selected for before and after project sampling. Selected sites may be vegetation management or riparian restoration projects. The intent is to select reaches below areas where a substantial amount of activity will occur. Samples from each stream type (based on channel types and ecological region) will be consolidated to give average values for each attribute and then compared to data from similar reference streams.

Comparisons will include: 1) attributes before and after project implementation; 2) attributes from "treated" streams with reference streams (by channel type); and 3) assessment of temporal variation by comparing reference attributes collected in difference years. Post-project sampling for some projects will begin during the 2004 field season. Consequently, results from this monitoring are not yet available.

## *3.7. Heavenly Valley TMDL*

In January 2003, a stream monitoring plan was submitted to the Lahontan Regional Water Quality Control Board by the Lake Tahoe Basin Management Unit in accordance with the *Water Quality Control Plan Amendments for the Heavenly Valley Total Maximum Daily Load* (Lahontan RWQCB 2003*).* As outlined in the plan, the following parameters have been and will continue to be monitored: stream flow and suspended sediment, physical habitat attributes described in the Region 5 Stream Condition Inventory (SCI) Handbook (USFS 2004), and macroinvertebrates.

Target conditions for these attributes, as defined in the TMDL implementation plan, are:

- *instream sediment loads:* maximum 58 tons/year (5-year rolling average)
- *SCI attributes*: improving trends in channel morphology over time
- *Pfankuch channel stability rating*: increasing trend over time from "poor-fair" to "good"
- *macroinvertebrate community health*: improving trends in benthic invertebrate community metrics over time, approaching conditions in Hidden Valley Creek.

SCI attributes and macroinvertebrates are being monitored at three sites on Heavenly Valley Creek and compared to data from two sites in Hidden Valley Creek, a reference stream. The USFS has proposed that the RIVPACS model described in Section 3.1 be used as one of several methods for evaluating macroinvertebrate community trends in Heavenly Valley Creek (e.g., compare O/E trends in Heavenly Valley Creek with respect to those in Hidden Valley Creek).

To enable these comparisons, baseline O/E ratios were calculated for each of the five monitoring sites. All three Heavenly Valley sites had O/E scores greater than two standard deviations

(sd=0.19) from the mean reference site score (O/E = 1.01). Consequently, the model provided addition evidence to support the listing of these sites as impaired. The model also supported the presumption that Lower Hidden Valley is a reference site (O/E = 0.97). However, the model did not predict the Upper Hidden Valley site to be in reference condition (O/E = 0.45).

There are several reasons why the model may have predicted the site to be impaired, even if its presumed reference state were true. The Upper Hidden Valley site is intermittent, but the reference site streams used to build the RIVPACS model are mostly perennial. This could explain why the observed taxa were so much lower than predicted at the Upper Hidden site. Moreover, such high elevation sites were not well represented among the reference sites used to develop the RIVPACS model (only nine out of 136 sites (<7%) were over 9,000 feet).

A system for calculating and applying multi-metric Index of Biotic Integrity (IBI) scores to Heavenly Valley data remains to be developed. As previously described, the USFS collaborated with other agencies in the development of a B-IBI for southern California. Provided funding is available, future work will likely focus on development of B-IBIs in the Sierra Nevada.

## *3.8.Herbicide Monitoring*

USFS Pacific Southwest Region has conducted water quality monitoring of herbicides since 1991. Eight forests have monitored for glyphosate, five have monitored for triclopyr, and nine have monitored for hexazinone. Bakke (2001) synthesized the results of these studies and they are summarized below.

Glyphosate and triclopyr were rarely detected in surface water, as expected from their chemical characteristics (Table 19). Detections were associated with use within riparian areas or poor implementation of BMPs. Hexazinone has been detected numerous times in both surface and ground water, which is also expected based on its characteristics. If label direction and BMPs are followed, detected amounts of hexazinone are usually less than 10 parts per billion (ppb).

**Table 19 – Water quality monitoring of Region 5 herbicide projects, 1991 – 2000**

| Herbicide | Total Samples | With No Detectable Residues | 0-10 ppb | 11-30 ppb | 31-50 ppb | 51-100 ppb | 101-600 ppb | Maximum observed concentration [11] |
|---|---|---|---|---|---|---|---|---|
| Glyphosate | 104 | 103 | 0 | 1 | 0 | 0 | 0 | < 25 ppb |
| Triclopyr | 43 | 30 | 12 | 0 | 0 | 1 | 0 | 82 ppb |
| Hexazinone | | | | | | | | |
| - Surface water | 580 | 245 | 301 | 16 | 4 | 8 | 6 | 600 ppb |
| - Groundwater | 103 | 78 | 25 | 0 | 0 | 0 | 0 | 2.1 ppb |

[11] Where limit of detection (LOD) may be higher than a reported concentration, the maximum has been listed as "less than" (<) the LOD.

#### 3.8.1.1. Hexazinone

There were no detectable levels of hexazinone in 245 of 580 samples (42%) of the surface water samples. Of the samples with detectable levels, 90% were below 7 ppb and 95% were below 15 ppb. Effects to aquatic insects and fish are not expected until levels greatly exceed 1,000 ppb and the current EPA Health Advisory level (HA) is 400 ppb.

For groundwater, 78 of 103 samples (76%) showed no detections of hexazinone. Almost all (95%) detections in groundwater were at levels very near limits of detection (<1 ppb) and the highest level detected was 2.1 ppb in very shallow lysimeter holes (2 feet deep). Once hexazinone is in shallow groundwater, lateral movement can be extensive (e.g., hexazinone was detected approximately 450 feet down gradient from one treated unit). Together, results from surface and groundwater data imply that hexazinone in groundwater can be a source of surface water contamination over a long period of time, regardless of implementation of BMPs to directly protect surface water.

#### 3.8.1.2. Glyphosate

There were no detections of glyphosate in water associated with reforestation projects, except those ascribed to sample contamination. Glyphosate was detected in only one of twelve samples associated with noxious weed treatments in the riparian zone. The detected concentration of 15 ppb is below any level of concern for human health or aquatic resources.

#### 3.8.1.3. Triclopyr

The few detections of triclopyr not associated with accidental or erroneous applications in water were all less than 2.4 ppb. These levels are below any aquatic levels of concern. The detection that resulted in the highest level of triclopyr (82 ppb) was caused by the absence of an untreated buffer on an ephemeral stream. This concentration does not represent a substantial risk of harm to humans or the environment. Monitoring results suggest that untreated streamside buffers of greater than 15 feet in width reduce risk of water contamination to near zero.

## *3.9. Range Monitoring*

The Region initiated a comprehensive Range Monitoring Program in 1999. Objectives, methods, and results of this study are described in detail in *USFS Region 5 Range Monitoring Report* (Weixelman et al. 2003) and are summarized here.

The purpose of the program is to monitor long-term trends in range conditions across the Region by establishing permanent plots on key sites. The project will provide critical information needed to inform management decisions regarding grazing. Specifically, it will develop an

ecological classification of rangelands based on vegetation, soils, and hydrology and quantitative scorecards for assessing meadow conditions and trends.

A total of 785 plots on key range sites have been established throughout the Region since 1999: 572 rooted frequency plots in meadows, 79 rooted frequency plots in annual grasslands, and 134 “green line” and cross section plots. To date, preliminary ecological classifications have been developed based on statistical analysis of data from the 785 permanent plots. Initial scorecards to rate ecological condition for monitored sites are expected in 2005. Data from twenty-four sites established in 1999 and reread in 2003 is currently being analyzed to evaluate possible short-term trends.

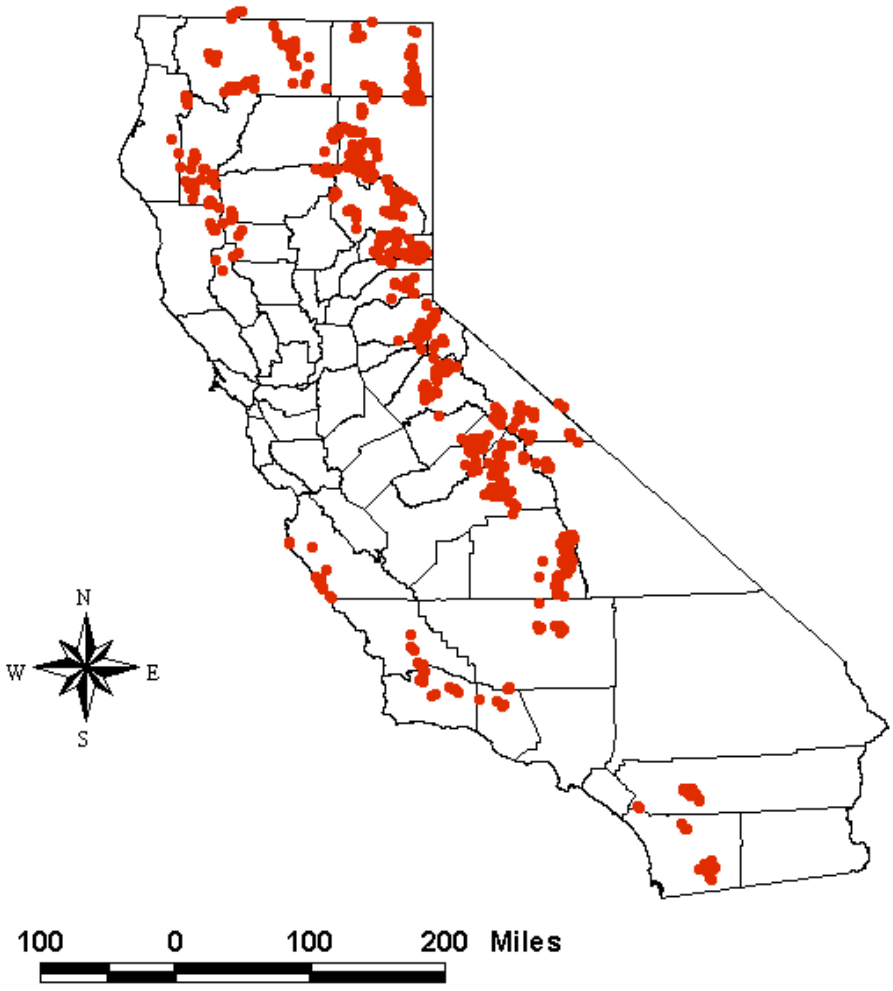


Figure 33. Distribution of all 785 range monitoring plots established from 1999 through 2003 across Region 5.

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